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A POLICY ANALYSIS OF USING UNIT
COSTS AS A MEANS OF PERFORMANCE
MEASUREMENT IN THE AIR FORCE
SCIENCE AND TECHNOLOGY PROGRAM

THESIS

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THESIS

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Hey sports fans... it's finally over!

Michael P. Avery

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Abstract

This study investigates the possible use of unit costs as a means of performance measurement in the Air Force Science and Technology (S&T) program. Using a policy analysis methodology, the author breaks the analysis into four phases. The first phase is called understanding the problem and incorporates the theory of management control systems, budgets, resource management systems, and identifies what the S&T program encompasses. The second phase is called developing policy options and identifies three distinctly different policies that satisfy the need for getting performance information into the hands of decision-makers. The third phase is called determining the impacts. During this phase each of the policies is evaluated based on weighted decision criteria and possible impacts are identified. The last phase is called selecting the best alternative. This phase states the conclusions reached from the analysis. It also identifies the limitations of the research and recommends areas needing further research.

This study found that unit costs are currently not the best way to determine S&T program performance. The technique of unit costs is currently not possible to implement because of a lack of total operational cost data and an undefined measure of laboratory output.

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I. Introduction

General Issue

As the Department of Defense budget gets smaller, in real terms, an increasing amount of emphasis is being placed on efficiency in managing resources within the department. Management control systems and budgets (which play a major role in the management control system) for organizations are designed to identify and track the use of resources in the organization as well as measure efficiency and effectiveness of their use. For purposes of planning and budgeting, the Department of Defense (DoD) uses the Biennial Planning, Programming, and Budgeting System (BPPBS), which is a process that has developed over several years, and is based on the concept of the program budget. Program budgeting does not address efficiency in the same sense that most people think of as efficiency. Rather than measuring the cost of producing an output (how the money is spent), the program budget concentrates on spending money on the right things (why the money is spent).

Specific Problem

The need for better efficiency in government operations cannot be traced to one particular event, rather, it has come about as a consequence of several events. Three of these are addressed below.

In August of 1989, the Office of the Comptroller in the Department of Defense notified the services that they were to start using cost-per-output measurements to enhance visibility of costs, contribute to better resource management, and foster a new culture within the department which emphasized cost reduction (Basso and Thomas, 1991:14; Dunlap, 1991:17). These cost-per-output, or unit costs, were to be used for resource allocation decisions. This policy was not to take effect all at once. Supply Operation was the first of several functional areas to receive resources based on unit costs for FY 1991. Future functional areas identified for implementation of unit costs include Accounting and Finance and Research and Development (Basso and Thomas, 1991:14).

Why should the Department of Defense choose to start using unit cost (also known as performance budgeting) information for resource allocation? Basso and Thomas suggest three reasons.

1. The Federal Government is under great pressure to reduce the budget deficit, therefore the DoD will continue to operate under tighter fiscal constraints.

2. Cost continue to rise. Unit costs place emphasis on cost and should help identify areas for improvement.

3. Programs that survive in the future will have to be fiscally fit and have aggressive cost managers.

Unit costs also are tied directly to organizational output. Program budgeting, on the other hand, emphasizes planning. Once the planning is complete, resources are distributed accordingly. Currently, the primary measure of efficiency is whether all of the funding for the fiscal year has been spent or obligated. This is not necessarily a good measure because it may incorrectly assume that managers are spending the funds in accordance with their organizational investment strategy. Emphasis on obligations and expenditures can encourage poor management practices. In fact, the high obligation rates toward the end of any particular fiscal year may not have any relationship to the work to be accomplished (Bowsher and Others, 1980:11). As an example, if a manager's performance is evaluated based on his or her ability to obligate the funds for their program, and their program is currently behind schedule (in actual work accomplished), there would be a temptation to start purchasing items which may only be indirectly associated with the program. This would increase the obligation and expenditure rate for the program. However, if the program was behind schedule, the actual work accomplished could still be behind schedule. To make matters worse, this type of spending activity could also cause the program to end up over budget as well as behind schedule. "We still have a lack of appropriate execution feedback to the senior

leadership. Managers need output oriented feedback but we still have the input oriented obligation rate" (Sourwine, 1988:16).

As stated earlier, the DoD Comptroller memorandum was not the only reason for needing to pursue the idea of performance budgeting for the Air Force laboratories. Several changes were happening at the same time which brought the issue to a head.

The management of DoD laboratories has come under attack in recent years for being inefficient and ineffective. The DoD spends approximately $6 Billion per year for research in 76 laboratories, and Congress is asking whether the benefits are worth the costs (Kellam, 1991:29). Both the Office of Technology Assessment and the Defense Science Board identified problems in transitioning technology from the laboratories into weapon systems and suggested restructuring the laboratory system (DoD, 1987; OTA, 1989:7). These studies, along with the Defense Management Review directed by Secretary of Defense Cheney, led to the Laboratory Consolidation Study of 1990, according to Lt Col James Crowley, USAF, who was a member of the OSD team (Crowley, 1991). This consolidation study attempted to identify duplicity and inefficiency in the laboratory system. Although very little duplication was found, OSD still contemplated consolidating the labs under the direct control of OSD. This would have meant that the services would have lost direct control of technology development.

In a counter offer to OSD, the Air Force offered to consolidate the 14 labs under its control into 4 "super labs" and reduce its laboratory personnel significantly.

In addition to the above efficiency drivers, there is a cultural change going on throughout DoD to adapt Total Quality Management (TQM) principles. According to Armand V. Feigenbaum, originator of the concept of total quality control, quality starts with knowing the customer's quality requirements and doesn't stop until the product is placed in the hands of the customer (Schonberger and Knod, 1991:145). From this statement, it is apparent that for an organization to produce a quality product, they must know who their customer is, and what their output is. A major item of concern with TQM is the ability to measure output in order to tell whether or not you have improved. There should be an attitude of continuous improvement for the quality of the product.

Although much has been done in the past two years to deal with the aspect of better effectiveness, the problem of a lack of efficiency measurement for the labs still exists.

Research Questions

The questions that were researched fell basically into two broad categories. First, how do you measure performance in the laboratories? Second, how should this information be used in managing the Air Force labs?

In attempting to measure the performance of the lab, one must distinguish between efficiency and effectiveness. A good example which clearly makes the distinction is the recent incident during the war in the Persian Gulf where an F-15E fighter/bomber shot down an Iraqi helicopter with a 2000 lb laser-guided bomb. Was it effective? You bet! Was it efficient? Not really. The helicopter could have been more efficiently destroyed by using the 20mm guns of the F-15. Efficiency is basically a ratio of inputs to outputs, so this research must identify what the laboratory's inputs and outputs are. For instance, what type of funding does the lab receive? How are military salaries accounted for? Does the lab have to pay for rent, electricity, heating, etc out of its research and development budget? If so, does it come out of basic research, exploratory development, or advanced technology development funding? Does the laboratory have an operating budget for daily operations? If so, how is it developed? What is the output of the lab? Who uses the output (who is the customer)? Is the output quantifiable?

How to use with the information is another matter. We need to know how, and by whom the lab's performance is measured. Is the entire laboratory's performance measured, or are the laboratory's program's performance measured? Who is responsible for the performance? What incentives are there for managers to reduce costs? What managerial reports are needed at various levels of command so that decision-

makers have the information they need? Who are the decision makers in the Science and Technology program for the Air Force? If the Air Force labs had to compete for research dollars against the Army, Navy, Industry, and Universities what would they need to do differently and what information would be necessary?

Scope of the Research

This analysis will be limited to studying management control system of the United States Air Force Science and Technology Program. Specifically, the Wright Laboratory at Wright-Patterson AFB, Ohio will be studied. The Wright Laboratory is the Air Force's largest lab and should provide a good picture of the Air Force labs in general. No classified material will be used, and no attempt will be made to evaluate any portion of the Air Force's Special Access programs (usually referred to as "Black" programs).

II. Literature Review

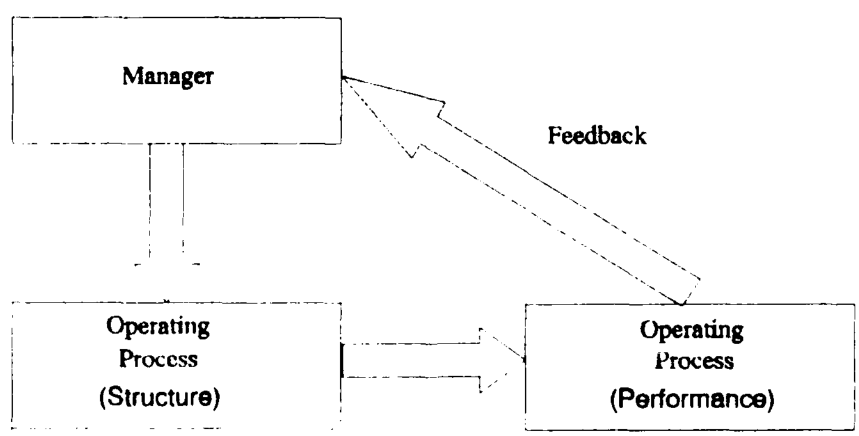
To adequately analyze unit costs and their use in the Air Force Science and Technology program, one must first establish a firm understanding of management control systems and the role of budgets within the system. Next, we must look at the Department of Defense planning and control systems by first looking at their historical development and then look at how the current process works and how it is structured. This chapter then concludes by defining what the Air Force Science and Technology program is, and its process of establishing an investment strategy.

Management Control Systems

"Management control is defined as the process by which management assures that the organization carries out its strategies effectively and efficiently" (Anthony and Herzlinger, 1980:3). All organizations exist for a reason. Some generate profit, others may provide a service to the community. The efficient and effective operation of these organizations requires some sort of mechanism (or system) with which management can plan, implement and control. This mechanism is called the management control system and consist of both structure and process (Anthony and Young, 1984:5). What is a Management Control System (MCS), and what does it do? To answer these question, first we'll take

a look at how an organization operates, that is, its process, and second, we'll look at the structure of a MCS.

Figure 1 shows the process of a basic control system in an organization. It shows a simple control loop consisting of a manager, operating process and a feedback loop. The operating process is split into two sections - structure and performance. The distinction is made because the operating processes structure is part of the organizational planning process and the performance portion is part of the control aspect (Shishoff, 1990). Planning is defined as "... a delineation of goals, predictions of desired results under various ways of achieving goals..."

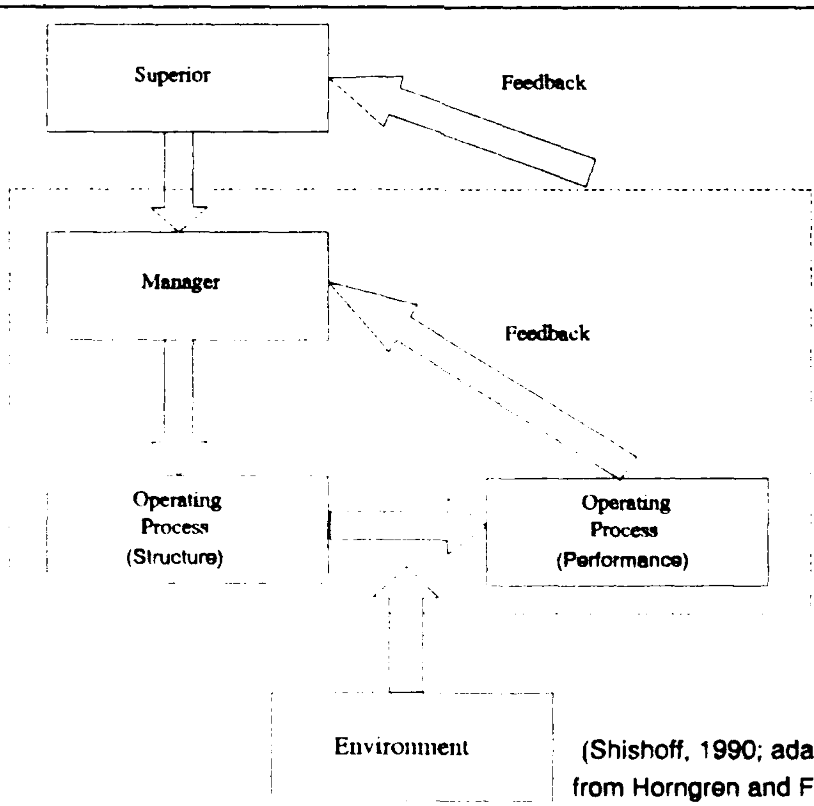


(Shishoff, 1990; adapted from Horngren and Foster, 1987:3)

Figure 1: Elements of a Control System

(Horngren and Foster, 1987:3). Control, on the other hand is what implements the plans and provides feedback on the performance. As a whole, the process is what produces something, such as a widget. Information is provided to the manager, via the feedback loop. The manager can then make adjustments to the system based on the performance feedback. This control system can represent the operating process of a larger system, which can be the operating process of an even larger system (see Figure 2).

The composition of a control system consists of three general levels, each of which require differing types of information to operate effectively and efficiently. The



(Shishoff, 1990; adapted from Horngren and Foster, 1987:4)

Figure 2: Elements of a Control System

highest level can be thought of as the Strategic level. This level is responsible for providing the overall organizational goals and vision, as well as providing the needed resources to the lower levels. People at this level require aggregate performance information at least quarterly and may need some type of annual report. The next level of the control system could be considered more tactical in nature. Some authors refer to this level as management control. This level might be represented by a division of a major corporation, for instance the Pontiac Motor Division of General Motors Corporation. Managers at this level need aggregate information from each of the individual manufacturing plants which report to it. These reports would be weekly or monthly. The lowest level is where the actual organizational output is produced. It is sometimes referred to as the operational level. At this level, supervisors are transforming operating plans to products using people and materials. Feedback must be quick. It may take many forms such as verbal communication, memos, letters, or weekly reports, and include various measures of performance (Herbert and others, 1987:591; Daft, 1986:318; Thorn, 1986:19).

Peter Drucker states that management controls must satisfy seven specifications (Drucker, 1973:498-504). They must be:

1. economical;
2. meaningful;
3. appropriate;

4. congruent;
5. timely;
6. simple; and
7. operational.

For a control to be economical, Drucker suggests that the system report only the minimum information needed in order to have control. The system also needs to be cost-effective. "The primary criterion for judging system A versus system B is cost-benefit" (Horngren and Foster, 1987:374). To be meaningful, Drucker states that the events being measured or reported must be significant. This, of course, is a matter of relativity. What is significant at one level may be totally inappropriate at the next. In non-profit organizations resources usually come from outside sources. "Other resource providers, particularly legislators and grantors, require reports prepared according to their specifications, and the system must be designed to meet these requirements, whether or not the organization finds such information useful for its own purposes" (Anthony and Young, 1984:245). Drucker describes control appropriateness as being the most important specification because if you are going to control something you'd better make sure you are measuring the right thing. He describes congruence in terms of measurement accuracy. "A measurement does not become more 'accurate' by being worked out to the sixth decimal when the phenomenon measured is at best capable of being verified within a range of 50 to 70 percent" (Drucker, 1973:501). The timeliness of reports is

also relative. Hourly or daily reports are appropriate at some levels but not at others. Simplicity speaks for itself. Drucker says that complicated controls do not work, they only confuse. For controls to be operational, they must be focused on action. The information must get to the person who can make the decision or control the action. In some organizations, decisions and information flow along informal lines as opposed to the formal organization chart. "A prime challenge for systems designers is to discover whether some or all of the informal information system is leading to successful decisions. If so, the designer should attempt to formalize those parts of the informal system" (Horngren and Foster, 1987:376).

Drucker also mentions that control systems have a fundamental, incurable basic limitation. They are controls and measurements of human operations, or social institutions. Even the best designed control system will be difficult to implement and operate if managers, at each level, are not motivated. "Top managers should predict how system A will affect the collective actions of managers in comparison with system B. To make such predictions, managers must be conscious of the likely motivational effects (goal congruence and managerial effort) of systems" (Horngren and Foster, 1987:377).

Earlier in this chapter, it was mentioned that budgets are key elements of the management control system. As such,

it is appropriate that we take time to discuss what they are and describe various types of budgets.

Budgets

What is a budget? Expressed in very broad terms, it "...is a plan expressed in monetary terms" (Anthony and Young, 1984:357). Webster defines it as "... a plan for the coordination of resources and expenditures" (Webster, 1977:144). Yet, another defines a budget as "... a quantitative expression of a plan of action and an aid to coordination and implementation" (Horngren and Foster, 1987:139). Although each of these definitions describes the budget as a plan, there is more to it than that. Budgets consist of both planning and control. One accounting text described planning and control as so strongly interlocked that it wasn't necessary to make the distinction between them and throughout the text referred to management planning and control systems as control systems (Horngren and Foster, 1987:3). Another text, though, made a significant distinction between planning and control. The authors describe the interrelation as the planning-control continuum which takes place within a strategic management framework (Herbert and others, 1987:589-593).

Along with having aspects of both planning and control, budgets also have distinct phases and differing purposes. One author describes four phases of a budget cycle as: planning and analysis; policy formulation; policy execution;

and audit and evaluation (Lynch, 1985:11-14). Differing purposes for budgets include: planning; management; and control. The planning aspect of budgeting is associated with greater rationality in the decision-making process. It stresses the importance of analysis, data, and categorization of the budget to facilitate analysis. Budget reformers might insist on having a greater emphasis placed on planning if they feel there is a lack of logic between resource allocation and organizational goals. If a management orientation is stressed, the budget is considered a tool for assisting in executive decision-making. Management concerns are focused on effectiveness and efficiency of operations. Decentralized control is emphasized to improve managerial flexibility and responsiveness. Control is needed to ensure policies are carried out. For instance, when Congress appropriates money for a specific purpose, it must be able to make sure money is used for the purpose for which it was originally intended. Extreme budgetary control, however, can lead to inefficiency due to limited managerial flexibility (Lynch, 1985:45-46).

There are many types of budgeting techniques, each with its own special purpose. Since this research is interested in evaluating the effects of budget policy in the Air Force Science and Technology program, and the Department of Defense has undergone several changes with regard to its budgeting process, it is appropriate that one discuss

various budgeting techniques. The following sections will look at four types of budgets: Incremental; Zero Based; Program; and Unit Cost (or Performance). The first three types have already been used in the Department of Defense, and the fourth is beginning to be implemented.

Incremental Budgeting. Incremental budgeting is probably the simplest form of budgeting or decision making. In incremental budgeting, the current year's budget serves as the base for the next year's request. For instance, say you spent $600 last year on long distance telephone calls. If this amount seemed adequate, you might take this amount as an estimate of the amount to be spent next year plus a little more to account for increases in price due to inflation. A typical budget format would include the past year budget (PY), the current year budget (CY), the budget year (BY) and the difference between the budget year and the current year (BY - CY). Of course, at the heart of this type of budgeting lies the assumption that the work accomplished in past years was satisfactory and still required in the future. A version of incremental budgeting would be to allocate a certain percent of a total budget to a specific purpose. An example of this would be if you wanted to spend 5% of your income on entertainment. The total amount of money spent on entertainment would then go up as your income increases (of course it could also go down if income decreased). Critics of incremental budgeting argue that this type of budgeting cannot (or does not in

practice) respond quickly enough to significant changes in upper management policy (Lynch, 1985:45). Of course, management policy is driven by changing organizational requirements from internal and external sources. For instance, the Air Force may feel they need a new weapon system to counter a new threat, but Congress may be more interested in reducing the federal budget deficit. A budget that would allow for radical changes in policy would be one that had no set funding base for existing programs. This is the concept behind Zero Based Budgeting.

Zero Based Budgeting.

> Zero base budgeting is an approach to public budgeting in which each budget year's activities are judged in a self-contained fashion, with little or no reference given to the policy precedents of past years. (Lynch, 1985:50)

Peter A. Pyhrr developed the zero-based budget process for Texas Instruments Inc. during 1969. He later helped Governor Jimmy Carter of Georgia adapt ZBB for use in government. Jimmy Carter and his assistants brought the ZBB process to the Federal government when he was elected President in 1974. In a 1977 article, Pyhrr stated that the basic idea, or focus, behind the ZBB approach, is to give the executive answers to two questions. First, are the current activities efficient and effective? Second, should current activities be eliminated or reduced to fund higher-priority new programs or to reduce the current budget? He goes on to identify the following four basic steps in the ZBB process (Pyhrr, 1977:1-8).

1. Identify "decision units". A decision unit is a meaningful element of work, which means that it will be different for each organization. It essentially breaks down work efforts within an organization to the level of detail that management needs in order to make decisions. These decision units can then be grouped together to form decision packages, which form the building blocks of the program and budget analysis.

2. Analyze each decision unit within the decision package. The decision package is a document used for budget/program analysis and contains information that would be typically found in documentation used in decision making. Information such as:

- Purpose/objective
- Description of action
- Costs and benefits
- Work load and performance measures

The ZBB decision package does contain two additional pieces of information that makes this process rather unique. The decision package requires that alternative methods of accomplishing objectives and various levels of effort for each alternative be identified. Identifying alternatives requires that several meaningful alternatives to the current mode of operation be investigated. Identifying levels of operation starts with determining the minimum level of acceptable funding needed to sustain the efforts of the organization and then developing incremental work packages

which could increase the level of effectiveness of the organization. These incremental work packages are what are defined as "decision packages". The use of decision packages allows managers to use marginal utility theory in determining the best mix of projects to fund. Several decision packages could be submitted, but in many cases a minimum level is submitted along with the current level and a package that would increase the level of funding.

3. Evaluate and rank all decision packages to develop the appropriation request. This is an important task within any budget formulation process because, logically, some things in life are more important than others. The idea is that each of the decision packages are rank-ordered, and when the money runs out, the line is drawn. Any package below the line does not get funded.

4. Prepare detailed operating budgets reflecting decisions approved in the budget appropriation. This step is needed because most Executive Branch budget proposals are subject to a Legislative review and are subjected to changes. Once the appropriations are approved, the detailed operating budget can be prepared.

ZBB has its good points and its bad points. The good points, theoretically, are that it forces managers to identify alternative methods of doing business instead of continuing under the "We've always done it that way!" syndrome. It also forces managers to determine minimum levels of effectiveness. Many of the bad points to ZBB can be directly related to the above good points. For instance,

how do you determine how much National Defense is needed as a minimum. How do you measure the marginal effectiveness of additional units of National Defense? ZBB can also turn into a "paper monster which buries executives in an avalanche of documents" (Lynch, 1985:51).

Budgets are tools of managers and executives, and as such need to be cost effective to be used. Lynch wrote that the Department of Agriculture used a ZBB approach to budgeting in 1964 in addition to their normal incremental budgeting approach in order to compare the two processes. He stated that "...except for a few small decisions, the department reached the same conclusions as it would have reached with the less expensive incremental approach" (Lynch, 1985:50).

Program Budgeting. Program budgeting (also called Planning, Programming and Budgeting (PPB)) is an attempt to use a more rational approach to budget formulation by using marginal utility theory, systems analysis and cost/benefit analysis. Its focus is on planning, and as such, it takes on a more economic perspective rather than the traditional accounting view of budgeting which focuses on control. Schick makes a connection between differing types of manpower needed for different types of budgeting. He describes that in a control-oriented budgeting environment, accountants are needed, in a management-oriented budget environment public administrators are needed, and in the planning-oriented budget environment economists are needed

(Schick, 1966:258). Since the focus of program budgeting is planning, it requires people to ask why money should be spent on a particular program, as opposed to just asking how much.

In the late 1950's and early 1960's program budgeting was hailed as being revolutionary, but many of the concepts were not new. "Budgeting always has been conceived as a process for systematically relating expenditure of funds to accomplishment of planned objectives. In this important sense, there is a bit of PPB in every budget system (Schick, 1966:244)." A form of program budgeting was used in the United States as early as 1907 in New York, but the program budgeting that most people are familiar with is associated with the RAND corporation in the late 1950's and institutionalized throughout the Department of Defense by Robert McNamara, Secretary of Defense under President Kennedy.

Program budgeting requires that the vision, goals, and priorities of an organization (and chief executive) be firmly established and known throughout the organization. This is because in order to get the most output for the dollar you need to know if program "A" is more important than program "B" to achieving the goals of the organization. In this sense, the budget constitutes the executive's investment strategy for the agency. In order for executives to make rational decisions with regard to the operation of their agencies, budgets needed to be broken into functional

(or mission) areas as well as line-items. For instance, the Secretary of Defense needs to know how to distribute funds to programs such as Strategic Offense, or Research and Development rather than how many soldiers, aircraft, ships or tanks he should purchase (although he will also need to know exactly how many of each of these to ultimately purchase). To do this, the organization's, or agency's, budget is broken into major functional programs. One text suggested that there be no more than 10 major programs in order to make the process workable.

> The optimum number of programs in an organization is approximately 10. The rationale for this number is that top management cannot weigh the relative importance of a large number of disparate items, and the programs should be limited to the number that management can so weigh. (Anthony and Young, 1985:235)

Each major program is then subdivided into discrete sub elements. In the Department of Defense, these sub elements are called program elements (PE). Each PE includes information on needed resources such as manpower and capital expenditures. These PE's are the basic building blocks of the budget and make it possible to aggregate budget information in many ways, facilitating better planning and programming. For instance, planners might need functional area information which groups program elements into major programs, whereas managers at the operational level might need the budget in terms of individual items, such as tanks or aircraft. Financial reporting for both internal and external purposes is facilitated by using program elements

(Sourwine, 1988:16). The ability to mix and match this budget information is called crosswalk.

> A common crosswalk is between the so-called program structure and the appropriation structure. The program structure is used by the executive to make major decisions on program direction. The appropriation structure is the language used by the legislature to make its decisions. Both decision makers are significant so the agency and the budget examiners must be able to translate from one language to the other - the crosswalk is the device which permits translation. (Lynch, 1985:141)

For this to work effectively, the program elements must be mutually exclusive in order to avoid double bookkeeping. For instance, if you had two PE's which identified the resources needed for the operation of two different aircraft systems, and they both included the manpower in the engine maintenance shop, when the data is sorted to identify how much manpower is needed, it will show twice as much as actually needed. Therefore, each piece of equipment, each personnel authorization must be identified under a specific PE.

Another important aspect to PPB is the use of a multi-year projection of program needs. This five or six year projection of outputs, in terms of capabilities and required resources, allows managers to see possible impacts to decisions on a larger scale. For instance, chopping five million dollars from a program this year might save you five million this year, but it could cost you billions five years from now.

While program budgeting has its good points, a major flaw in the underlying logic exists. For program budgeting to work effectively, persons in the budgeting process must be able to shed any parochial biases.

> PPB implies that each participant will behave as a sort of "Budgetary Man," a counterpart of the classical "Economic Man" and Simon's "Administrative Man." "Budgetary Man," whatever his station or role in the budget process, is assumed to be guided by an unwavering commitment to the rule of efficiency; in every instance he chooses that alternative that optimizes the allocation of public resources. (Schick, 1966:257)

The problem is that persons at each level of the budgeting process are subject to internal and external pressures, such as deadlines, differing individual and organizational goals, and have a tendency to locally optimize instead of striving for system optimization. That is, that they will attempt to maximize the use of resources from their perspective (Marutollo, 1984:13-18). For program budgeting to work properly, people must be willing to recognize the possibility of higher priority needs in other organizations. This is a very difficult problem to overcome and leads to what Marutollo called the "irrational" in what would otherwise be a rational process.

Unit Costs. Unit costs (also known as performance budgeting) and program budgeting have many things in common, and confusion still exists in distinguishing between the two. Some of this confusion was a result of the 1949 Hoover Commission which suggested specific budget reforms, and

coined the term "performance budgeting", but in the same report, the task force used the term program budgeting.

> Among writers there was no uniformity in usage, some preferring the "program budgeting" label, others "performance budgeting," to describe the same things. The level of confusion has been increased recently by the association of the term "program budgeting" (also the title of the Rand publication edited by David Novick) with the PPB movement. (Schick, 1966:250)

Some authors describe performance budgeting as an extension of program budgeting (Lynch, 1985:44), but Schick makes a significant distinction. Performance budgeting is management oriented with its emphasis on assessing work efficiency, whereas program budgeting is planning oriented with its emphasis on analysis to provide executives input into a rational decision-making process. He goes on to state that "... in performance budgeting, work activities are treated virtually as ends in themselves, in program budgeting work and services are regarded as intermediate aspects, the process of converting resources into outputs" (Schick, 1966:251). While both PPB and Performance budgeting address efficiency, PPB's concern for efficiency is at a different level.

> Performance budgeting uses unit cost data to determine whether existing functions are being carried out efficiently. PPB uses marginal cost data to determine whether different functions or activities could be implemented to attain the desired objectives more efficiently. (LaCivita and Pirog, 1991:21)

This is a good point at which to discuss unit costs and economic theory. The name "unit cost" is misleading in some respects. Unit costs do not measure the cost of producing a

particular unit of product, rather, they represent an average cost at a certain level of output. By taking the total average cost of producing, say 100 aircraft you can get a unit cost per plane. The reason you must specify the level of output, is that unit costs vary at differing levels of output. For example, let's say that the Air Force is developing an experimental aircraft that will destroy strategically relocatable widgets. If the Air Force buys 200 of these aircraft, the unit cost might be $45 million. However, if the Air Force only purchases 100 of the aircraft the unit cost might jump to $60 million. The higher unit costs for fewer aircraft is due, in part, to having fixed costs spread across fewer aircraft and higher costs for input materials because of smaller lot purchases. This might sound like the more you buy, the cheaper the unit price becomes, but is not necessarily the case. At some point, it will become more expensive to produce aircraft, and for 300 aircraft the unit cost might be $50 million. This is shown in Figure 3. The increase in production costs at higher output levels is due to what economists call diminishing marginal returns. If a company wanted to continually produce these aircraft at a high rate of output, it might invest in a larger plant and newer equipment which could reduce the unit costs back to, perhaps, $45 million.

This process of using unit costs may sound simple enough, but nothing is ever as simple as one first imagines. The first problem is to determine the input costs, both

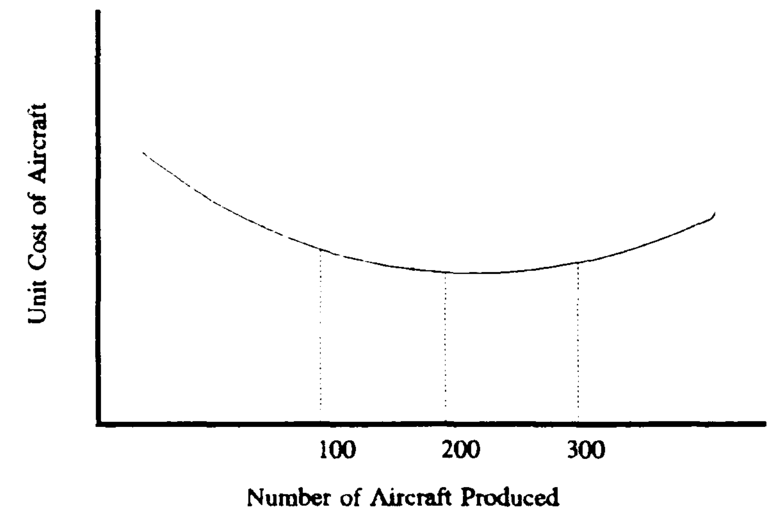


Figure 3: Unit Cost Relationship

direct and indirect. Direct costs might include the cost of labor and material to manufacture a product. Indirect costs include things such as employee dining facilities and parking lots and can actually contribute significantly to the total cost of an organization. Indirect costs (or overhead costs) can be as much as 1000 percent of direct labor costs (Miller and Vollmann, 1985:142). These indirect and "hidden" costs can be difficult to determine for a particular product line if a company manufactures more than one product in the plant. The problem can be aggravated by management arbitrarily assigning indirect costs. For instance, if product A requires much more indirect costs than product B, but the costs are spread equally to each, it

would make product A appear better (cost wise) than it actually is.

The next problem is to determine the output of an organization. Output is broken into two parts (primary and other). Primary output consists of output associated with the main mission of the organization. Other output is considered important but not included in the main mission (Comptroller, 1990:7-8). For a company that produces a physical product, like an aircraft or automobile this might not be too difficult. For non-profit and service organizations the problem becomes more difficult. The best example of this is national defense. What is the output of national defense? War? Peace? Defense? How do you measure it? And if you could measure it, how much is enough? Economist might argue that if the goal of national defense is to deter war, the country should purchase just enough national defense to keep us out of war. Of course, this would mean the country would exist in a state in which it was perpetually at the brink of war. Since that would not be either socially or politically acceptable the country is forced to purchase more national defense than is needed to deter war.

What are the advantages of performance budgeting and unit cost data? They stress effective use of resources by concentrating on the internal operations of the organization and the cost of doing business (LaCivita and Pirog, 1991:21). The concept of unit costs also includes debiting

an organization's budget for depreciation and capital consumption and is a step toward making an organization responsible for capital investment decisions (Dunlap, 1991:17).

> In government a "bad" capital decision contributes to budget deficits, taxpayer burdens, and inefficient allocation of resources but no individual or activity is ever held accountable. (Dunlap, 1991:17)

As stated earlier, performance budgeting is management oriented, and as such, treats the budget as a tool for management decisions. One article also describes unit costing as being a resource tool in which allocation of resources can be determined, and a productivity tool for measuring improvement (Basso and Thomas, 1991:15).

When using performance budgeting to measure managerial effectiveness, caution must be applied. In ideal circumstances managers would be responsible for all aspects of operations and have the authority to make capital improvement decisions. If a manager is forced to use old facilities, or buildings which are too small or too large for what is needed, the result may be high unit costs for which the manager has no control (LaCivita and Pirog, 1991:23).

Now that the basic concepts of budgeting have been identified and differentiated, it is time to review how the Department of Defense uses them. We'll start by looking at the history of program budgeting in DoD and then look at its resource management system, or control capability.

History of Program Budgeting in the DoD

Prior to 1961, the Department of Defense used incremental budgeting techniques. The Department's budget was, in some instances, merely a flat rate based on a percentage of the total Federal budget or the Gross National Product and did not necessarily correlate with defense strategy. For instance, during the Truman administration, the Pentagon was allowed a fixed portion (one third) of the federal budget. What was even more amazing is that from 1950 to 1951 (the beginnings of the Korean conflict), President Truman reduced the military budget by 8 percent because he was determined to keep the federal budget balanced and revenues had dropped (Korb, 1977:335). Also, during the Eisenhower presidency, a policy was established to keep the defense budget below 10 percent of the Gross National Product (Korb, 1977:335). Even when the Department had received its "share" of the Federal budget, the services received fixed portions. The Air Force received 47%, the Navy 29% and the Army 24% (Berenguer, 1986:24). When President Kennedy came into office, he decided to change that. He asked Robert McNamara to take the job of Secretary of Defense. McNamara agreed to do so, but with the condition that he could make defense policy and manage the Department (Korb, 1977:336). "Robert McNamara entered office as SECDEF determined to be an active participant in preparing DoD's budget and choosing the weapons developed and purchased by the military departments" (DoD, 1983:18).

The way he chose to control the Department was through the budget process. He understood the concept that whoever controls the money in an organization controls the organization. He decided to incorporate a process called Program Budgeting, which had been studied by the Rand Corporation since the early 1950's (Novick, 1964:6).

This budget process has gone through many changes since being introduced into DoD. In fact some have said that the only thing that hadn't changed was the name (Berenguer, 1986:24), but even that has changed since the introduction of the biennial budget.

The first major change to the process came under Melvin Laird, who became SECDEF in 1969. The Office of Systems Analysis, which was created by Secretary McNamara, no longer sent forward independent program proposals. Instead, they reviewed program proposals from each of the Services using specific budget ceilings. When President Carter came into office, he brought Zero Based Budgeting (ZBB) with him. Even though ZBB was a drastically different method of developing and justifying the Defense budget, the basic building blocks of Program Elements remained the same (Berenguer, 1986:25). The major difference between ZBB and PPBS was that ZBB required each program to rejustify itself each year, whereas PPBS was designed to be more of an incremental budgeting process concentrating only on the changes to already established programs. Note, that this is a significant difference in how Schick describes PPB and how

Novick implemented it within the DoD. Schick's version of PPB required a full review of all programs much like ZBB, but without requiring identification of alternative solutions or decision packages. After President Carter left office, the ZBB process was discarded. "It simply did not work" (Puritano, 1981:571). "As a former Assistant Secretary of Defense (Comptroller) wrote, most of the good parts were not new, even if ZBB itself was a fraud" (Berenguer, 1989:25).

The Department of Defense began submitting a biennial budget with the 1988/1989 President's Budget. The PPBS is now called BPPBS for the Biennial Planning Programming and Budgeting System and switched from a Five Year Defense Plan (FYDP) to a Six Year Defense Plan (SYDP) starting with the submission of the FY 92-97 POM (DAF, 1989:ii). For consistency, BPBBS will be used throughout the remainder of this paper. The BPPBS consists of both process and structure. This is the topic of the next two sections of this paper.

<u>The BPPBS Process</u>. The Biennial Planning, Programming and Budgeting System has, as the name implies, three distinct phases. The planning phase is the first step in the process. It starts as much as five years prior to budget submission with Service planners providing input to the Joint Staff for incorporation into the National Military Strategy Document and the Defense Planning Guidance. These documents provide guidance to the Services based on national

security policy and threat estimates. The issuance of the Defense Planning Guidance ends the planning phase and begins the programming phase.

Once the Defense Guidance is issued, the Services begin an intense process of prioritizing their requirements for the next six years (SYDP). These requirements are assembled into what is called the Program Objective Memorandum, or POM. Each Service submits its POM to the Office of the Secretary of Defense (OSD) where it is reviewed by the OSD staff. Adjustments to the Service POMs are accomplished through what is called the issue process, where issues are raised (usually in the form of proposed reductions to the POM) and the services are given a chance to reclamma. The Deputy Secretary of Defense provides each service with guidance based on the alternatives to the POMs through a document called the Program Decision Memorandum (PDM). The new POM, as modified through the PDM, serves as the new baseline for the start of the budgeting cycle. This ends the programming phase.

The budgeting phase begins with the Services taking the adjustments from the PDM's and preparing a Budget Estimate Submission, which is the actual budget proposal to OSD. OSD and the Office of Management and Budget (OMB) hold hearings to gather information on the Services's current year budget estimates. Changes as a result of the OSD/OMB hearings are issued to the Services in a Program Budget Decision (PBD). Once the budgets have been approved by OSD and OMB, they

become part of the President's budget to Congress (DAF, 1989:13-41).

Structure of the DoD Budget. The Department of Defense budget is divided into 11 major functional programs, which are called Major Force Programs - (01) Strategic Forces; (02) General Purpose Forces; (03) Intelligence/Communications; (04) Airlift/Sealift; (05) Guard and Reserve Forces; (06) Research and Development; (07) Central Supply and Maintenance; (08) Training, Medical and Other; (09) Administration; (10) Support of Other Nations; and (11) Special Operations Forces. Each major force program is further subdivided into program elements, which is the basic building block of the DoD and Air Force budget.

The Program Element is a eight digit alpha-numeric code designed to identify a mission capability and the amount of resources (manpower, facilities, and equipment) needed to provide that capability (DAF, 1989:52). The Program Elements are mutually exclusive. That is, mission capability identified under one Program Element will not show up under another Program Element. For instance, all exploratory development work relating to aerospace flight dynamics in the Air Force is found under the Program Element 0602201F and nowhere else. The Program Element provides a way for managers to arrange budget data in multiple ways for multiple uses depending on whether it is for internal management use, or external reporting. This capability is

called crosswalk. For instance, if the Secretary of Defense (SECDEF) wants to see how much the Air Force is spending on Strategic Forces, a report can be produced listing the appropriate Program Elements, like the B-1 and B-2 bombers, and the Peacekeeper missile. The data can also be sorted to produce reports which shows Congress how many personnel are assigned to this mission area.

The concept of the Program Element is invaluable because of the way the U.S. Congress appropriates funding. Congress appropriates money in categories which more closely resemble line-items or objects-of-expenditure, such as, Research and Development, Military Construction, Procurement, Military Personnel, and Operations & Maintenance. The Program Element allows for both line-item and mission oriented planning. Figure 4 shows how the Major Force Programs cut across each of the DoD organizations, and how Congressional appropriations cut across organizations and programs. Figure 5 takes a particular slice of Figure 4 (Strategic Forces) and shows how Program Elements cut across appropriations for each program. "Program elements provide a much more flexible means of viewing resource management information than the rigid appropriation structure" (Sourwine, 1988:16). They tie the budgeting and programming phases together. This is because during the budgeting phase, Program Elements are grouped together by appropriation for Congress to understand, and during the

programming phase the Program Elements are grouped by Major Force Program (DoD, 1983:19).

Resource Management System in DoD

What is the DoD resource management system (RMS) and how is it different from the BPPBS? The RMS is "... all the individual resource management programs and systems pulled together. It is all systems used in concert to obtain, control, and account for the total resources we have available to accomplish the mission" (USAF, 1977:2). The difference between the BPPBS and the RMS is that the RMS takes over where the BPPBS leaves off. The BPPBS is

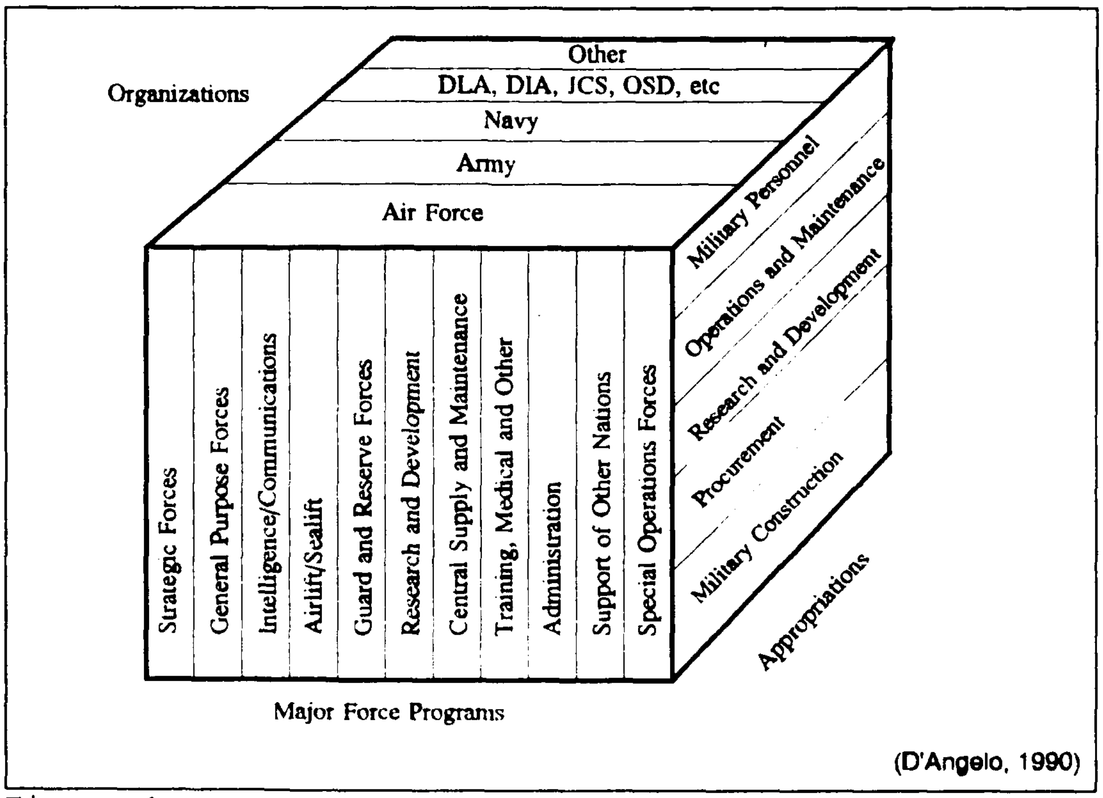


Figure 4: DoD Budget Structure

concerned with the planning and budgeting of resources and the RMS is concerned with the control of the resources (implementation and performance feedback). The RMS uses a combination of codes which represent a particular responsibility or cost center as well as a element of expense/investment code. With these codes, an organization can keep track of which cost center is using certain commodities. Feedback is provided to resource managers through reports generated by the computer in the base supply system. Some reports are standard reports which are generated daily, weekly and monthly, but others are generated at the request of the resource manager. Feedback

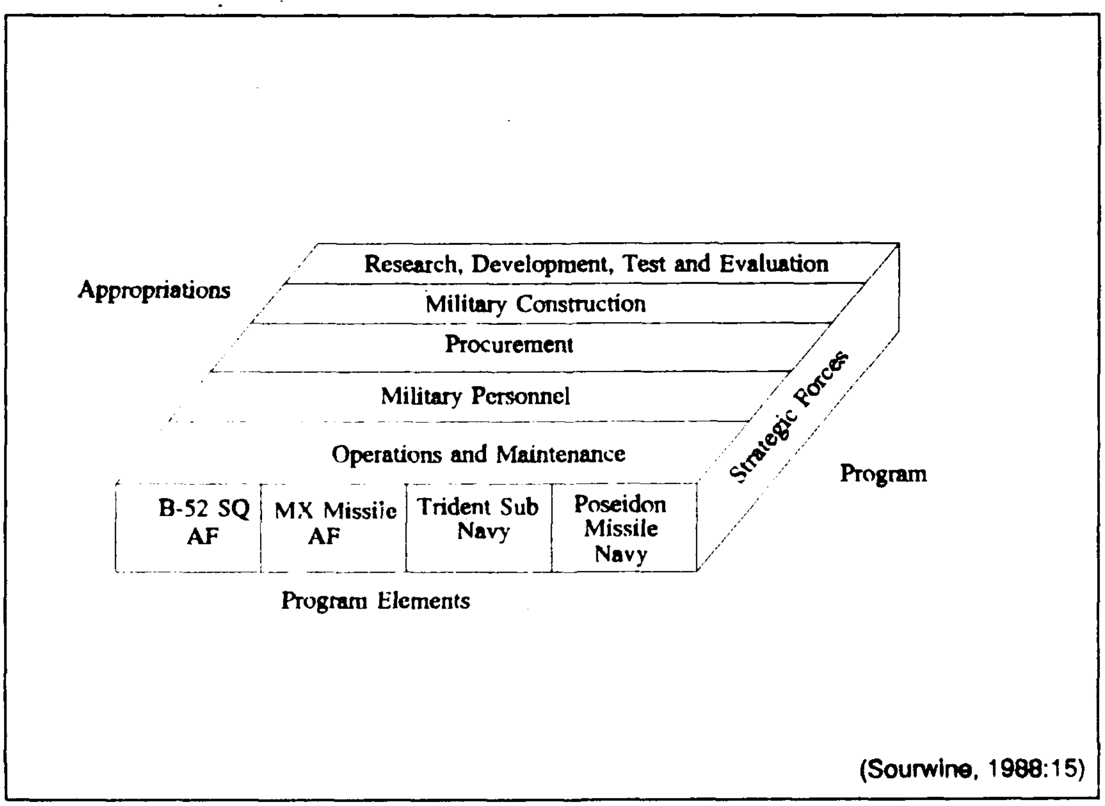


Figure 5: Program Element

is also provided to outside organizations (headquarters) by aggregating information by program element. This information can then be used by the higher level of management for resource management decisions. Now that we've discussed budgets and resource management systems and how they apply to the Department of Defense, we'll turn our attention to the Science and Technology program.

What is Science and Technology?

The Air Force Science and Technology (S&T) program is a specific portion of the overall Air Force Research and Development program. It is most closely associated with efforts conducted at the Air Force laboratories, but also includes research contracted to industry and grants to universities. Figure 6 shows how the S&T program is organized. The Air Force Acquisition Executive (AFAE) is located in the Pentagon, and is the head of all Air Force Research and Development. This includes all weapon system acquisition as well as the Science and Technology program. As the head of R&D, the AFAE has several Program Executive Officers (PEO) reporting directly to him. One of them is the Technology Executive Officer (TEO). The TEO and his staff reside at Air Force Systems Command Headquarters. He is responsible for the management of the S&T program and the development of the investment strategy of the program. The first tier under the TEO, shown in the figure, are the four "super laboratories" - Phillips Lab (PL), Rome Lab (RL),

Armstrong Lab (AL), and Wright Lab (WL). The organizations under PL and WL are now called directorates. They are what used to be laboratories under the old system (pre laboratory consolidation). Actually, looking at the paper organization of S&T, the old and new organizations aren't very different. PL used to be named the Space Technology Center and had the same organizations reporting to it. The only real difference (on paper) between the old and new organizations is that the old Armament Laboratory, at Eglin AFB, is now a directorate under Wright Lab. Research within the S&T program consists of three areas: Basic Research (6.1);

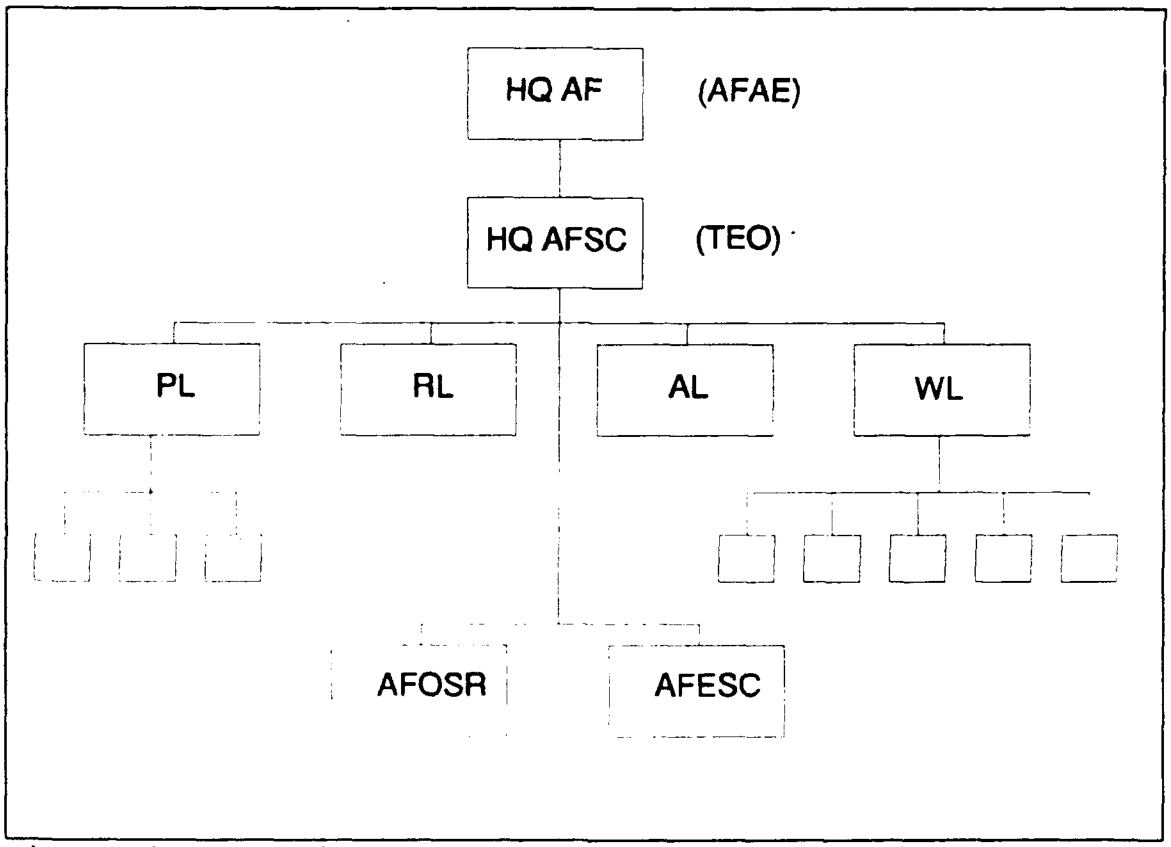


Figure 6: The Science and Technology Organization

Exploratory Development (6.2); and Advanced Technology Development (6.3A) programs, and is sometimes referred to as the Air Force technology base, or "tech base".

Basic Research. The Basic Research portion of the Air Force S&T program is designed to gain knowledge of phenomena in Defense related areas. It consists of two program elements. The first PE is entitled In-house Laboratory Independent Research and has less than 4 percent of the total 6.1 funds. In 1961, Defense Secretary McNamara mandated that each of the Services set aside a fixed portion of their research funding to conduct in-house research. This in-house research, called In-House Laboratory Independent Research (ILIR), is conducted at the discretion of the laboratory director and does not have to go through the same bureaucratic justification process as the rest of the S&T budget (DoD, 1985:6F-1). The second PE is entitled Defense Research Sciences and constitutes the majority of the work (96.1%) in the basic research area. This PE is responsible for the conduct of Air Force related basic research at Air Force laboratories, universities, and in the defense industry. It consists of 13 major projects such as physics, structures, chemistry, mathematics, electronics, materials, fluid mechanics, energy conversion, terrestrial sciences, atmospheric sciences, astronomy and astrophysics, biological and medical sciences, and human resources (DAF, 1990:1).

Exploratory Development. Exploratory Development is a step up in the evolutionary chain of research and development. It is the phase where scientists and engineers take the knowledge gained in basic research and apply it to actual hardware. For instance, in exploratory development, new computer generated aerodynamic designs of jet engine compressor blades would be manufactured and tested to determine the aerodynamic efficiency and mechanical integrity. There are thirteen 6.2 program elements - one for each of the 13 Air Force laboratories before they were consolidated into 4 "super" labs. Despite the fact the labs have been consolidated, there currently is no plan to reduce the number of program elements to align them with the new laboratory structure (Mitchell, 1991).

Advanced Technology Development. This phase of development builds upon the knowledge gained in the exploratory development phase. It takes component technology and tests it in an operating environment, but stops short of building hardware that could be considered prototypes. Continuing with the example of compressors for jet engines, during this phase, the new compressor would be tested in a real environment. Specifically, it would be tested in a complete engine to see how it interacts with the rest of the engine components. Because this phase of development is expensive, several experimental components are tested together, if possible. For instance, a new one-of-a-kind jet engine may be built consisting of all

experimental hardware. This phase of development is heavily dependent on industry to build and test the new emerging technologies. A direct benefit of having industry deeply involved in the actual manufacturing and testing of these new technologies is that the knowledge is directly transferrable to current Air Force production programs or to commercial applications. In some instances, advanced technologies find their way into commercial products before they are transitioned into military products. There are currently twenty four 6.3A program elements. Four provide services to other major commands such as logistics system technology, or weather systems. The remaining twenty program elements provide advanced technology demonstrations. Of the twenty, three are pervasive, that is, they are generic to many systems (materials, structures, computers). Ten are major subsystems, such as aircraft and rocket propulsion or conventional weapons. Five are product line/demonstration and the remaining two are for space systems environmental interaction and Lincoln laboratory, and don't fit into the other categories very well (AFSC, 1988). The exact number of PE's for this area changes more than the other two because of continually changing needs of the services. Program elements in this area are added, dropped, or merged as emphasis on certain technologies change over time.

How does the Air Force develop its S&T budget?

Before 1987, the Air Force built its S&T budget in a typical incremental budget fashion. Research already underway was considered a fact of life, and the justification for funding revolved around plans for new research. Defense Guidance for S&T was vague, and nearly any research project could be rationalized as meeting this guidance. So, what was the formal process of deciding which projects would be accepted or rejected? In other words, what was the Air Force's investment strategy for S&T? In 1987, as part of the fallout of the 1985 Project Forecast II study conducted by Air Force Systems Command, the Director of the Air Force Science and Technology program, Brigadier General Charles Stebbins, directed that all new research projects be justified based on how they supported the 39 technology efforts identified in the Forecast II study. This attempt at defining an investment strategy for S&T was still vague, and consequently, as was the case with Defense Guidance, practically any research could be rationalized. Still, this was a significant step toward developing a formal strategy.

In 1988, the S&T budget process changed significantly with the creation of the Technology Area Plans (TAPs). The Technology Area Plans (one for each of the 20 technology areas) are published annually to document all on-going research at each Air Force laboratory, as well as include proposals for new research projects. The TAPs are a final

product of coordination and planning between the Air Force laboratories, Air Force Systems Command Product Division planning staffs, Major Commands, the Air Force Technology Executive Officer, the Scientific Advisory Board, and the Air Force Acquisition Executive (Seldon, 1990:5). Each TAP is approved by the Assistant Secretary of the Air Force for Acquisition. Once approved, the TAPs form the "heart" of the Science and Technology investment strategy. The approval of the TAPs also authorizes the laboratories to begin the new research programs proposed in the TAPs. One of the significant features of the TAP is the technology "roadmap". Each TAP has a roadmap, or graphic schedule, of each project within each technology area. It shows how the individual projects fit together and feed into upgrades to existing weapon systems, or into significant technology demonstrations (critical experiments). The roadmaps allow the TEO and AFAE to see how the projects and TAPs are interrelated and gives them some idea of the impacts of budget modifications.

Recent Events

Performance measurement has made significant advances in the past two years in the Air Force. The driving force behind the movement seems to have come from two places. The first driver can be identified with the Total Quality Management (TQM) movement. TQM requires that organizations focus on the customer and producing a quality product.

Quality being defined, by some, as meeting customer specifications and requirements. A major aspect of the TQM process is that the organization must know if they are improving, or not. To do this, output must be quantifiable/measurable. This has led to the development of metrics across Air Force Systems Command. A draft Command Metrics Handbook was distributed in April of 1991. In his cover letter, General Yates, AFSC Commander, quoted James Belasco who said "What gets measured, gets empowered and produced" (Yates, 1991). The S&T program, in turn, has developed their own set of metrics which attempt to measure how good of a job they (the labs) are doing. In other words, the metrics are designed to measure laboratory performance. They include such things as measuring the quality of support to users (as scored by Product Divisions and Major Commands), quality of technology (as scored by the Scientific Advisory Board), obligation and expenditure rates, and performance of Advanced Technology Transition Demonstrators (ATTD's). The ATTD's are 6.3A technologies for which there is a waiting customer. Each ATTD is required to have a signed Technology Transition Plan, which states that the laboratory will develop a particular technology sufficiently so that it can transition without too much risk by a certain date, at which time the customer agrees to accept the technology. The ATTD's are in the process of having baselines, with regard to cost and schedule, developed. The metric for the ATTD's is to track

how many ATTD's are behind schedule and how many have transition plans signed (McCormack, 1991). The S&T metrics were used for the first time this past spring at the laboratory annual technical review.

The second driving force behind the performance measurement movement came from the Defense Management Review (DMR), which was directed by Secretary of Defense Cheney in 1989. Two laboratory initiatives came about as a result of the DMR. The first was the Laboratory Demonstration program, which challenged the services to find better ways to run the laboratories. Modeled after the Navy's successful China Lake project, the services were to find better ways to hire and reward top-notch researchers, cut unnecessary red tape in contracting procedures, and upgrade aging research facilities. (DoD, 1990:2). The Air Force chose Wright Laboratory as one of its labs for this test. As far as this thesis is concerned, the significance of the Laboratory Demonstration program was the development of measures of effectiveness, especially in the area of laboratory productivity. Five indicators of laboratory effectiveness have been identified, 1) applications by industry for licenses of patented technologies; 2) average time to renew/acquire research equipment; 3) amount of laboratory discretionary research and development funds; 4) technical publications recognized by peer review; and 5) operational/user interface (DoD, 1990:B-1). Numbers 1, 4,

and 5 refer to laboratory output, which is extremely important when trying to determine unit costs.

The second laboratory effort to come about from the DMR was Project Reliance. Project Reliance was developed by the Air Force and Army in response to the suggestion that the service laboratories be consolidated. It has since become a tri-service plan. The concept behind this project is that a particular service laboratory may be recognized nationally as a center of expertise in a certain type of research. The other services would then rely on the lead service to conduct the research they need. Another version of this is where a small detachment of, say Navy personnel are assigned to an Army (or Air Force) laboratory, where they can focus on solving problems that are peculiar to the Navy (Vitali, 1991:1-6).

As identified in the above paragraphs, the concept of measuring laboratory performance is not unique to this thesis. Much of the work, though, focuses on either efficiency or effectiveness, and not both.

III. Methodology

This thesis analyzes the use of unit costs as a means of measuring performance of the Air Force Science and Technology program. For this thesis, this analysis takes the form of a policy analysis. What is a policy analysis? One author describes it as "... a broad form of applied research carried out to acquire a deeper understanding of sociotechnical issues and to bring about better solutions" (Quade, 1982:5). He goes on to state that a "... policy analysis searches for feasible courses of action, generating information and marshaling evidence of the benefits and other consequences that would follow their adoption and implementation" (Quade, 1982:5). A policy analysis can also be anything from an informal, individual effort that involves nothing more than hard and careful thinking, to a major research effort involving many people gathering data and using sophisticated techniques (Quade, 1982:5). To further identify what a policy analysis is, and why it was used in this thesis, it may be advantageous to describe what it is not. For instance, it is not a case study. Although this thesis involves some things that would be found in a case study, such as identifying the organization and key persons and how they go about their business, it (the case study) would fall short of helping to solve any problem (at least directly). The policy analysis, in contrast, is

action oriented, in which the analysts "... try to provide suggestions and guidance for courses of action to persons in authority or with power to change circumstances" (Brewer and deLeon, 1983:3). This thesis is also not a statistical analysis, although it could have used statistical methods to assist in the overall analysis. Other techniques, such as operations research, systems analysis, cost-benefit analysis, and cost effectiveness analysis are often employed in policy analysis studies (Quade, 1982:5). Again, the policy analysis is much broader, in that it may also take into consideration "... the political and organizational difficulties associated with public decisions and their implementation" (Quade, 1982:5). Quade goes on to describe three things that a policy analysis is not. First, it is not an exact science. It attempts to use methods of science, but its methods are not entirely scientific. "We must, in fact, sometimes do things we think are right but cannot completely justify or even check in the output of our work" (Quade, 1982:25). Second, the policy analysis cannot ensure that public policy decisions are made in the public interest. For instance, the decision-maker may be dishonest, or want to get "even" with someone. Third, it is not a tool for advocacy of an analysts views. Policy analysis should be unbiased (if that is possible) (Quade, 1982:25).

With that out of the way, let's now turn our attention to the literature of policy analysis to see what it suggests for a method of action.

Review of the Literature

The review of literature regarding policy analysis identified certain steps to be done in order to accomplish the analysis. The basic procedure is to first, help the decision-maker determine what he wants, second, investigate various ways of accomplishing it, third, determine the consequences of such policies (if implemented), and fourth, rank the possible alternatives according to criterion determined by the decision-maker (Quade, 1982:45).

Quade breaks the process into five steps that might be applied in the following order: objectives; alternatives; impacts; criteria; and model. By objectives, he means that the analyst must fully understand the objectives of the intended policy, and that of the decision-maker. Quade admits that this may not be possible in all instances, since the decision-makers may be multiple (Air Force, DoD, OMB, Congress, etc.). Alternatives means that options to solving the problem should be given. He goes on to state that the alternatives do not need to be perfect substitutes for each other. In other words, if the objective of the policy is to improve efficiency and effectiveness of the S&T program, unit costs may be one way, but other options are available that don't necessarily need unit cost calculations. Impacts

means that each policy option carries with it possible consequences that must be identified. Sometimes this includes identifying costs and benefits. Quade also states that there may be impacts associated with an option that the decision-maker has no control. These should be identified. Criteria is the step he associates with developing criterion, or standards, with which to rank the alternatives. If cost is important, it may be used to determine the best option at the least cost. Model is the step in which the analyst attempts to predict or at least indicate the possible outcomes that follow the choice of an alternative. "In the abstract, a model is nothing more than a set of generalizations or assumptions about the world..." (Quade, 1982:45-47)

Brewer and deLeon describe the process of policy analysis as a six step process. The first step, initiation, contains such things as recognizing the problem, as well as its context. This phase also should include the determination of the goals and objectives of the policy, and finally, it should generate various alternatives. The second step, estimation, is as the name implies. That is, it is the step where estimations of what is happening in the relevant "world" and what the possible impacts of implementing a particular policy will be. He points out that there is a danger in this phase of having multiple interpretations of reality (Brewer and deLeon, 1983:89). The next step, according to Brewer and deLeon, is called

selection. During this step the alternatives are ranked and the best is selected. Following the selection step comes implementation. They state that there are several factors that influence policy implementation. They are: source of the policy; clarity of the policy; support for the policy; complexity of the administration; incentives for the implementors; and resource allocation (Brewer and deLeon, 1983: 265-266). After implementation comes evaluation. Did the policy actually accomplish what it was supposed to do? Finally, they describe a final step that they call termination. "Termination generally refers to the adjustment of policies and programs that have become dysfunctional, redundant, outmoded, unnecessary, or even counterproductive" (Brewer and deLeon, 1983:385).

Method of Approach

Although it is important to follow up once a policy has been implemented, such as Brewer and deLeon indicated with their evaluation and termination phases, this analysis is limited to the preliminary steps. This is due to the fact that this thesis is interested in providing a decision-maker with information that will help choose and implement a policy. It cannot provide any analysis regarding policy evaluation or termination since that would require that the policy be implemented first. Time limitations do not allow this for this thesis. Consequently, this research will concentrate on phases, which we'll call understanding the

problem, developing policy options, determining impacts, and finally, selecting the best alternative.

Understanding the Problem. This phase was partially completed through the literature review found in Chapter II. It helped the researcher understand management control systems, budgets, resource management systems, and the Air Force Science and Technology program. Additionally, a great deal of time was spent determining how the S&T organization works. That is, how programs are managed and how information flows throughout the organization. Key personnel were also identified (by position). This was done by researching unpublished documents and through personal interviews and communications and is found in Chapter IV.

Developing Policy Options. One author described policy options as falling into a continuum that has incremental policy at its far left and fundamental policy at the far right (Majchrzak, 1984:31). Incremental policy is, as the name implies, implemented in small pieces. When trying to identify impacts of policy, it is sometimes best to study the policy changes in small pieces (Lindblom, 1959:84). This is because with major changes (fundamental policy) it may become difficult, if not impossible, to tell which particular aspect of the policy caused the change in the outcome.

When trying to develop possible policy options, one of the first options that comes to mind is to do nothing. In most policy analyses, this would be a legitimate option. In

this analysis, it is not. This thesis makes the basic assumption that the Department of Defense is interested in finding some method of determining efficiency and effectiveness in the Science and Technology program. Therefore, to continue operating under the current practice, is an unacceptable option (assuming that the current system does not measure efficiency and effectiveness to the extent needed). Although there are many possible policy options that could be evaluated for use as performance measurement of the S&T program, this research will only evaluate three. This is due to time restrictions. What this thesis intends to demonstrate, is that there is more than one way to account for S&T costs and evaluate its program performance.

The first option evaluated considers using unit costs as a means of determining program performance. It looks at problems associated with determining inputs and outputs in order to calculate a unit cost. The second option looks at using various programmatic feedback mediums which would get performance information into decision-makers hands in a systematic fashion. The third option looks at treating all of the S&T program costs as Product Division overhead. It may not be readily apparent how this third option is a measure of program performance. What it is actually doing is treating the S&T program as if it were too small to manage in great detail.

During this phase of the analysis, decision criteria are chosen (and weighted) with which to evaluate each of the

policy options. Under normal circumstances, the decision criteria might be selected by the decision-maker. In this analysis, since there was no sponsor, I chose the criteria myself based on Drucker's criteria for control systems and weighted them based on my personal experience.

Determining the Impacts. During this phase, each of the policy options was evaluated against each of the criteria. The evaluation included how the particular option impacts the S&T program. The options were given a raw score (based on the criteria), then a net score (after weights were applied).

Selecting the Best Alternative. This phase identifies the best option based on the highest net score. It also points out any weaknesses, or limitations, of the analysis.

For purposes of this thesis, the first three phases of the analysis are included in Chapters I, II and IV, while phase four (selecting the best alternative) constitutes Chapter V.

IV. Analysis

This chapter contains the bulk of the policy analysis. It begins by continuing with the first phase of the analysis, understanding the problem. This chapter starts out by looking at the context of the problem, as opposed to Chapter II, which dealt with its theoretical foundation. This is done by studying the Science and Technology organization. Since the policy to be analyzed is concerned with how information regarding efficiency and effectiveness can be used by decision-makers, we'll look at how both formal and informal information flows throughout the organization. The analysis then turns to its second phase, which is concerned with developing the different policy options. Finally, the impacts of such policy options are identified. This is done in conjunction with scoring the options, and is based on decision criteria which were introduced in Chapter II.

Information Flow Within the Science and Technology Program

Efficient, effective, and timely information is crucial to the operation of any organization. In an ideal situation, we like to think of information flowing along "neat" formal lines; not just top-to-bottom, but also bottom-to-top and laterally. This is often more theory than reality, since it is not always found in actual practice.

To apply this to the S&T organization, the analysis starts by looking at how information, in the form of organizational (executive) policy flows within the Department of Defense Science and Technology program. It then continues by looking at how programmatic feedback is transmitted and used.

Policy. Policy with regard to Science and Technology (S&T) within the Department of Defense (DoD) is formulated and transmitted in various ways. In this analysis, three particular methods were looked at: formal top-down policy dissemination; formal bottom-up policy formulation; and policy transmittal via the budgeting process.

Top-Down. Top-Down policy transmittal is, for this research, defined as those policies that are initiated at the strategic or tactical levels of management. As was discussed in Chapter II, program budgeting, such as that used by the DoD, requires that organizational and executive goals be specified and understood throughout the organization. National goals must be translated into goals for national defense, which in turn must be translated into goals for each of the services. Each service must then further refine the goals into goals for each of its major commands, which further refine them into goals for their responsibility centers. Since there can be several layers of responsibility, this can be cumbersome. In 1986, the Packard Commission recommended, at least for the defense acquisition community, that these layers be reduced to

three. Service Acquisition Executives were created along with Program Executive Officers (PEO's). At the same time, the Air Force created the position of Technology Executive Officer (TEO), which was responsible for the Air Force S&T program. Defense policy formally flows along the lines shown in Figure 7. As shown, defense policy is provided by the Defense Acquisition Executive (DAE) to the Air Force Acquisition Executive (AFAE), who passes it on to the TEO, who, in turn, passes it to the laboratory commanders.

S&T policy from the OSD comes in two major forms. The first is the Defense Planning Guidance, of which only a small portion is devoted to S&T. It is necessarily broad and doesn't give much actual guidance as to which technologies to pursue, or why. A second document used in the transmission of policy is the DoD Critical Technologies Plan, which identifies 20 technologies which the DAE, or his staff, feels are key to the future of national defense. These key technology areas are listed in Figure 8. The list is not prioritized. Thus, it provides little guidance for the application of resources.

Policy from the AFAE comes in the form of an annual letter to the TEO (see Appendix A for complete letter). In it, the AFAE makes specific recommendations with regard to technology programs. For instance, in the example he calls for an increase in emphasis for fuels and lubricants and a replacement for halon. He also finishes with a recommendation to eliminate certain programs from Philips

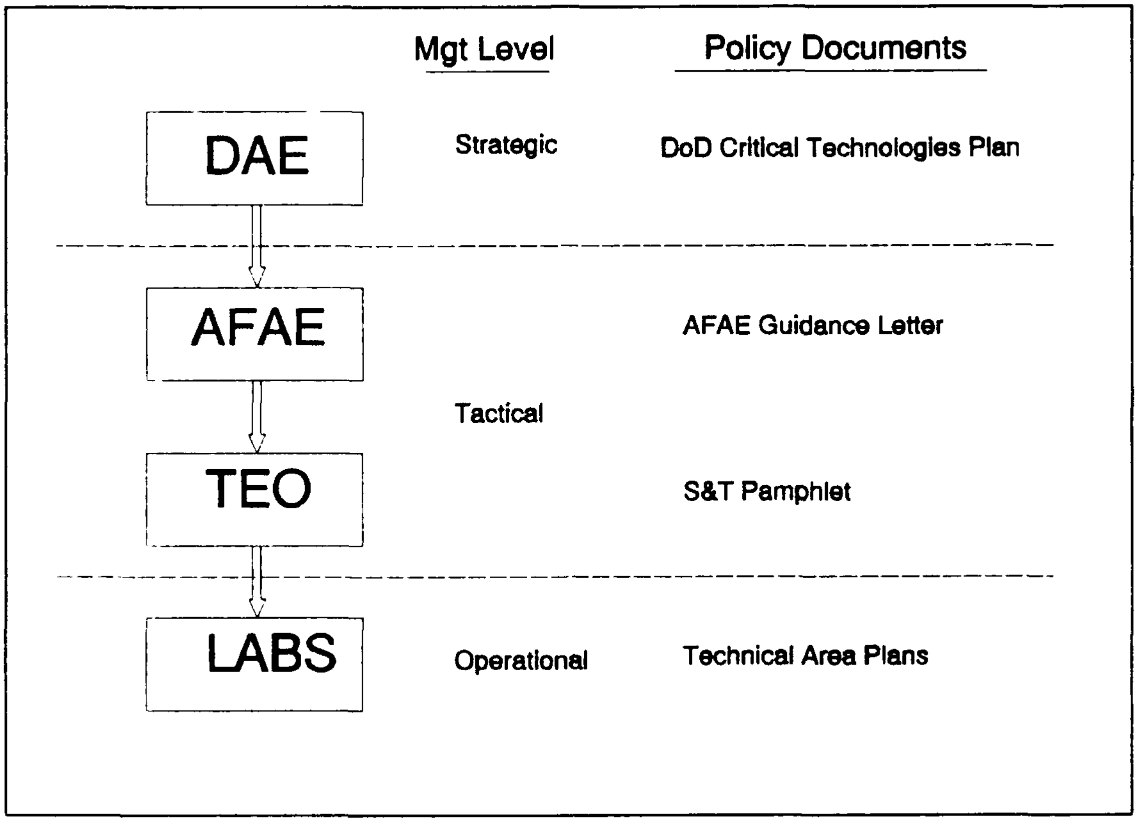


Figure 7: Formal Top-Down Policy Path

lab (Weapons lab). The AFAE also makes it perfectly clear that his priorities for the near future are the Basic Research (6.1) and Exploratory Development (6.2) areas. This type of information allows the TEO to develop investment and management strategies for S&T which will be in-line with the AFAE's priorities. The Technology Area Plans (TAPs) mentioned in the letter will be discussed later as a part of the bottom-up policy formulation.

The TEO policy directives to the individual laboratories takes the form of a pamphlet entitled "The Air Force Science and Technology Program" and is published annually. This pamphlet breaks the S&T program into 12 technology areas and describes the investment strategy for

Critical Technologies

1. Semiconductor materials and microelectonic circuits	11. Weapon system environment
2. Software producibility	12. Data fusion
3. Parallel computer architectures	13. Computational fluid dynamics
4. Machine intelligence and robotics	14. Air-breathing propulsion
5. Simulation and modeling	15. Pulsed power
6. Photonics	16. Hypervelocity projectiles
7. Sensitive radars	17. High energy density materials
8. Passive sensors	18. Composite materials
9. Signal processing	19. Superconductivity
10. Signature control	20. Biotechnology materials and processes

(DAF, 1990:5)

Figure 8: DoD 20 Critical Technologies

each. It also briefly describes how the 12 technology areas fit into the 20 DoD critical technologies scheme. This pamphlet serves a second purpose, which may be its most important. It serves as a brief, advocacy/informational document for customers and other interested parties of S&T. Customers include the operating commands, which provide the warfighting capabilities for the Air Force. Other interested parties could include DoD, Congress, Industry, and Academia.

Bottom-up. Bottom-up, as used in this research, is defined as policy or information that is formulated at the operational level of management. In the case of S&T, that level is the laboratory. Persons unfamiliar with the

workings of the Department of Defense might not know that the "guts" of many policy issues are actually formulated in a bottom-up approach. The Technology Area Plan is a good example. The process starts with AFAE guidance to the TEO, who then passes this information on to the laboratories regarding the content and format of the TAPs. Since the TAPs have been in existence for at least three years, the labs can currently start by making modifications to the last submission. This is probably a good place to describe the TAPs and their significance to the S&T program.

The Technology Area Plans, or TAPs are plans written by laboratory managers that describe the investment strategy of a technology area. The twelve technology areas are shown in Figure 9. The TAPs describe what has been done in the past year, what is currently being done, and what is expected to be accomplished in the near future. A unique feature of the TAP is the technology roadmap, which graphically shows how the individual projects within the technology area are linked together and what system/subsystem they are planning to transition into. This is an important feature for managers especially during budget adjustments because they can see the long term impact of cutting funding to a specific project. The roadmaps are shown in various levels of detail. For instance, one level might show information at the individual contract level, which could be used by the program manager, whereas an executive level roadmap might show the contracts aggregated into projects or programs.

Air Force Technology Areas

1. Aeropropulsion and Power
2. Air Vehicles
3. Avionics
4. Advanced Weapons
5. Civil Engineering and Environmental Quality
6. Conventional Armaments
7. Command, Control, Communications and Intelligence
8. Geophisics
9. Human Systems
10. Materials
11. Research
12. Space and Missiles

(DAF, 1990:39)

Figure 9: Air Force Technology Areas

Another significant feature of the TAP is that it serves as the approval document for new projects proposed by the laboratory. As an attachment to the TAP, the laboratory submits proposals for new projects. Once the TAP is submitted to the AFAE for approval, his staff has approximately two weeks to identify reasons for disapproval, otherwise they are approved by default. This automatic approval method was instituted to streamline the approval process.

The reason that the TAP can be considered a bottom-up process is that the document is written in the lab and forwarded upward for approval. The process looks something like Figure 10, where there may be an iterative cycle

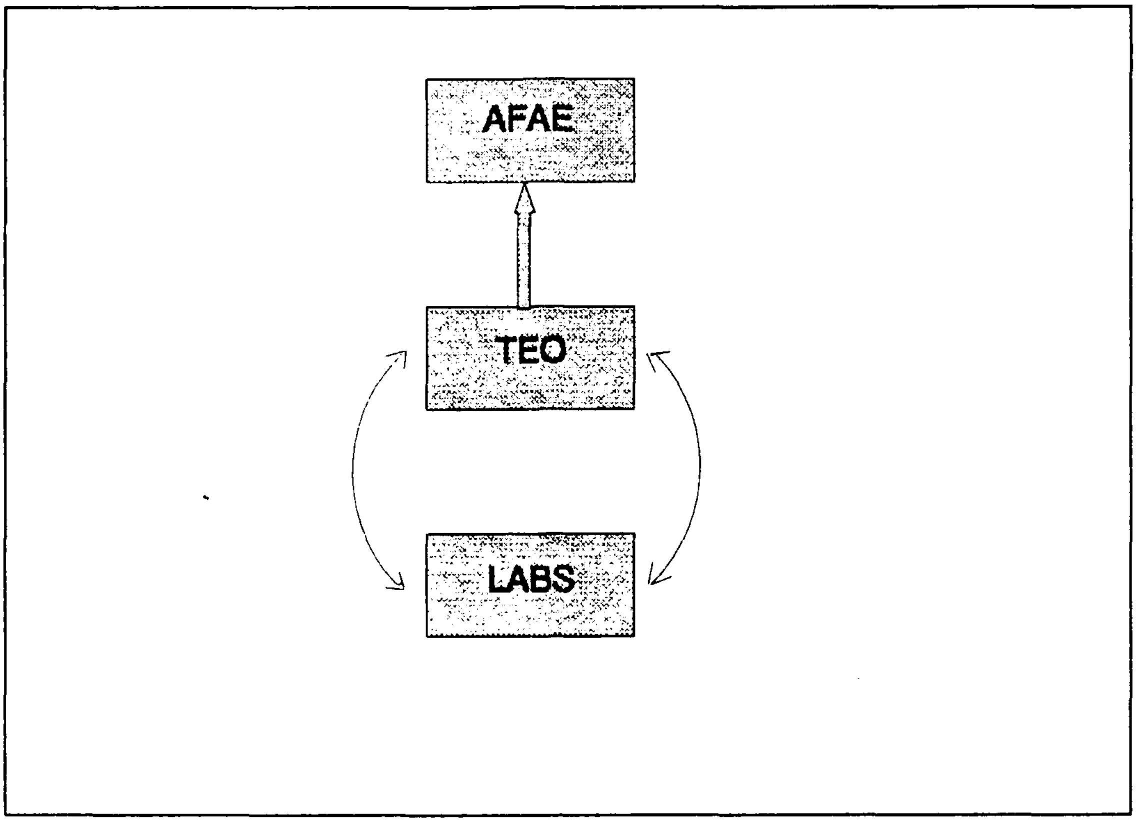


Figure 10: Iterative TAP Process

between the TEO and the lab until the document meets format and content specification, after which it is forwarded to the AFAE for approval. Once the AFAE approves the document, the TAP appears as though it is top-down policy since it is signed out by the AFAE. Of course, one must keep in mind that the TAP must conform to the guidance issued by the DAE, AFAE and TEO previously identified above. In some ways the TAP process resembles the budget building process in DoD. This process starts with top-down policy that is extremely broad in scope. The organizations at the bottom formulate their specific budgets which work their way up the chain of command. Since you can't do any work without money, and

thus, the budget itself transmits policy, we'll look at it next.

<u>Policy via the Budget</u>. As we saw in chapter two, the Department of Defense uses program budgeting as a way of making informed decisions with regard to resource distribution. As each layer of management within the DoD evaluates and "scrubs" its budget proposals, in theory, only the best budget programs survive. By the time the DoD budget is merged with the rest of the Federal budget and submitted to Congress for approval, it can be argued that the budget and policy is indeed rational and worthy of being approved without change, at least in the eyes of the executive branch. What happens when Congress receives the budget proposals? Well, in recent years some have argued that the budget proposals have been "dead on arrival" (D'Angelo, 1990). By authority of the United States Constitution, the Congress has the responsibility to appropriate the funds necessary to run the country. The Budgeting and Accounting Act of 1921 requires that the President submit a budget to the Congress, but this budget is only a proposal (Lynch, 1985:39). As discussed in Chapter II we saw that Congress appropriates money in different categories than the DoD uses them. The capability of "crosswalk", which is facilitated by the program element (PE) structure, allows both Congress and the DoD to separate the budget into pieces for their own understanding. The program element introduces a problem for the S&T program.

Although Congress appropriates money by major categories of appropriation, such as Research and Development, the budget committees and their staffs go through the appropriation by program element. The significance of this is that rather than having Congress tell DoD that they are spending too much money in S&T so that DoD can then adjust their budget according to their logically developed investment strategy, Congress adjusts individual budget levels of program elements. It is not unusual for Congress to require the Air Force to spend money on things that were considered less important by the Air Force. For instance, according to Captain Kevin Harms, manager of aeropropulsion and power technologies at Air Force Systems Command headquarters, in the past two years Congress has ordered that the Air Force spend millions of dollars in research devoted to the development of fuels from coal (Harms, 1991). The Air Force might not mind such adjustments if Congress had authorized additional funding to do the research. What usually happens, though, is that Congress tells the services to do the research, without providing additional funds. Thus the services have to reduce something else. This, of course, defeats the whole logic of the program budgeting process as far as the Department of Defense is concerned. When the appropriation bill is passed by Congress and signed by the President, the funding levels within the appropriation become law. It would be illegal for DoD to take this money from Congress and then try to shift it back to meet their

investment strategy. Once the appropriation is law, the money is apportioned through DoD to the services. Figure 11 shows how this works. This figure is actually an oversimplification for effect, because the money does in fact go through the different layers of management. It is shown this way to emphasize that the major players who were instrumental in developing the budget and investment strategy can now only make minor adjustments to the appropriation. For instance, the maximum flexibility allowed within any S&T program element is $4 million. This means that management can only add or subtract a maximum of $4 million to a PE in any given year. To make larger

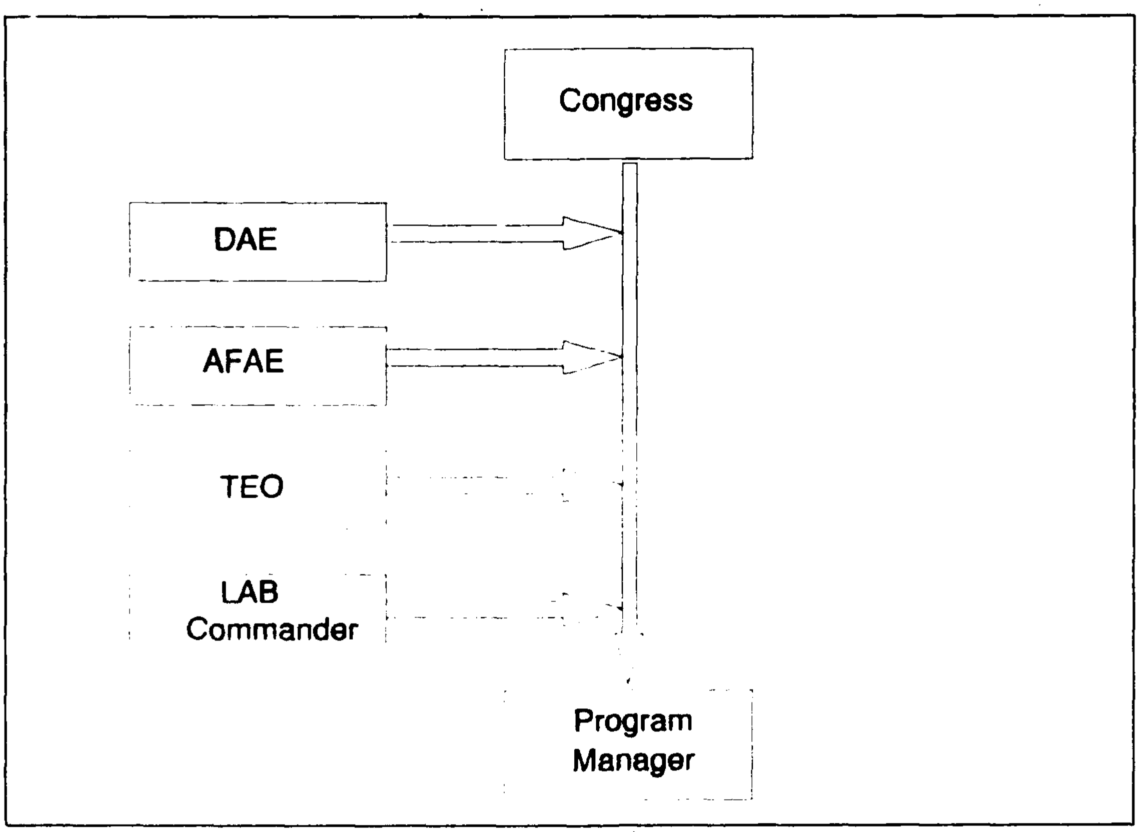


Figure 11: Policy transmission via the budget

adjustments requires approval of Congress. In this manner, Congress adds its own policy to the S&T program, which may not be the same as the DoD's. This is not to say that this system is good or bad. Rather, it identifies a major stumbling block to the service's strategy in developing the S&T program. Some managers have found ways to get around adjusting appropriations to program elements. According to Walker Mitchell, former Deputy Director of the Aero Propulsion and Power Laboratory, managers simply move work efforts between program elements. The only way they can legally do this is to redefine the work, where possible, in such a way that it legally fits into another program element. This technique gives laboratory management some flexibility, but it must be used with caution since it only applies in certain cases (Mitchell, 1991).

There may be many ways that policy can be developed and implemented within an organization. The above examples only highlight some of the major ways. Although policy is important, in that it gives direction for the laboratories to follow, policy does not get any work done. The laboratories and contractors actually do the work. We'll next look at how programmatic feedback is transmitted and used within the S&T program.

Programmatic Feedback. As discussed with regard to management control systems in Chapter II, feedback is used to give the manager performance information with respect to

some operating process. The manager can then use this information to adjust resources accordingly. Programmatic information includes such things as cost, schedule, and performance of a project. Therefore, programmatic feedback is that timely information dealing with project/program cost, schedule, and performance which is sent up the chain of command to provide decision-makers with the information they need to make efficient and effective resource allocations.

What type of feedback is currently used in the S&T program? By far, the most pervasive measure of performance is in the form of obligation and expenditure rates. These rates measure how much money the program manager has actually spent or contractually obligated. A major drawback to using obligation and expenditure rates for performance measurement is that they focus on means and not ends. That is, how much money is spent on a particular project may, or may not, have any relation to how much work actually gets accomplished. For a manager, or his superior, to allocate resources efficiently, he or she must know the project's actual performance. The manager, at each level within the organization, should have access to this performance information.

As policy is transmitted along formal lines in an organization, one would also expect feedback to follow similar lines in order to keep decision-makers informed. The next section looks at how feedback is transmitted within

S&T, whether or not it is formal or informal, and whether or not it is programmatic.

Figure 12 is a busy diagram, because it attempts to show lines of communication within the S&T program. Formal lines are shown as solid lines and informal lines as broken lines. For the purpose of this research, formal is defined as written, periodic reports or periodic briefings. Informal is defined as all other means, such as telephone conversations, memos, or ad hoc visits.

As one would expect, the project manager is at the bottom of the feedback chain. All programmatic information originates from his or her hands. Formal reporting of

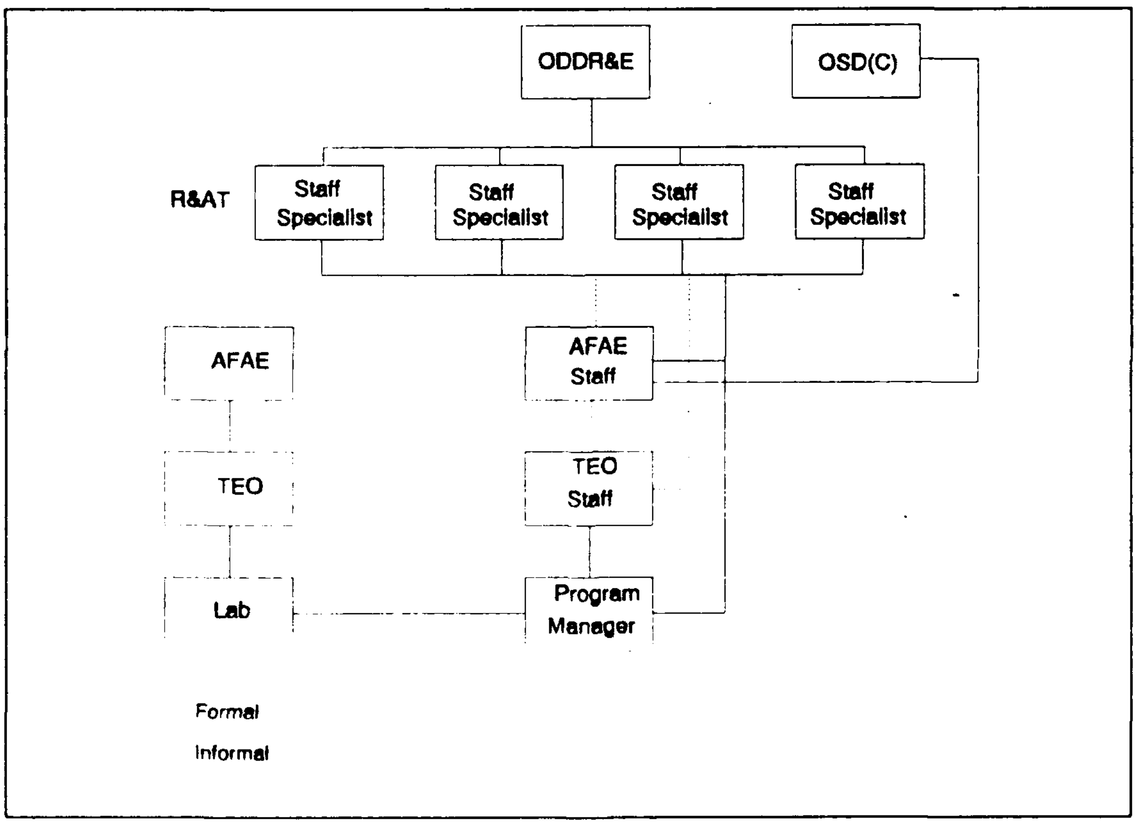


Figure 12: Feedback channels within S&T

programmatic feedback takes the form of the quarterly report, which is required by the Program Management Directive (PMD) issued by the AFAE staff. Courtesy copies of this document are sent to the head of each directorate (formerly called a laboratory director prior to the formation of the super labs), the laboratory commander, and the TEO staff. The quarterly report is the only formal periodic report that transmits programmatic feedback. All other forms of feedback are either ad hoc or not programmatic, or both.

The remaining lines in Figure 12 that are identified as being formal are annual briefings given at various levels. There are annual briefings given to the TEO by the program manager through the lab commander. These discuss the Technology Area Plan (TAP), which is an investment strategy, not programmatic feedback. Another annual review is presented to the OSD Staff Specialist for a particular technology. These briefings are given by the program manager and are designed to present technological information and not programmatic feedback.

There is one other formal line of feedback that must be discussed, that being the annual briefing to the OSD Comptroller, OSD(C), by the AFAE staff. This briefing is the annual review of obligations and expenditures by program element. Not all program elements are reviewed each year. Whether or not a program element is reviewed depends on how well the program manager has spent the money. This review

is significant because the Comptroller has the authority to cut funding from a program, especially if he feels that the manager doesn't have a good reason for poor obligation or expenditure rates. Some have argued that even a good reason isn't enough. One AFAE staffer expressed his frustration with the process by relating a story of a neighbor who came over to borrow a hammer. When the neighbor asked to borrow the hammer the man replied, "I can't right now I'm making soup." To which the neighbor responded, "What does that have to do with letting me borrow your hammer?" "Nothing", replied the man, "but if I don't want to let you borrow the hammer, any excuse will do!" The same is true in the case of the Comptroller. This particular staff member believed that if the Comptroller is going to cut funding, he's going to cut it regardless of the manager's reason for low performance.

Figure 12 also shows that there is no central person on the OSD staff who is responsible for the overall S&T investment strategy and performance. Each of the staff specialists is responsible for certain technology areas. It also shows that the responsibilities for technology and programmatic performance is split between the Research and Advanced Technology (R&AT) staff and the Comptroller offices. This split is not unique in the S&T program. Within the laboratories, for instance, the business side of the laboratory is frequently separate from the technology/research side. Recently, on a tour of a lab

within the Armstrong Aeromedical Research Laboratory, at Wright-Patterson AFB, a scientist was proudly showing his experiment, when someone asked him if he used any sort of management tools, such as PERT or CPM to keep track of his project's performance. He responded that he was a scientist and didn't worry about money!

At the OSD level, though, the split is significant. The Comptroller is put in the position of adjusting programs, even though he was not involved in determining the initial investment strategy, and he may not have as much relevant information available when the decision is required. It could be argued that this situation results in the Comptroller shifting the delicate balance of Air Force strategy by cutting individual program elements without adequate appreciation for the impact of such cuts on the strategy. It is also important to note that the OSD level is the only point within the military S&T program that the Comptroller can somewhat unilaterally impact S&T policy in this way. If the Air Force needs to reprogram money after the appropriation is passed and the funds are apportioned, the Comptroller at lower Air Staff or Major Command levels tells the AFAE staff what it needs, and the AFAE and TEO decide where the money should be cut. In this manner, this investment decision resides with the persons who formulated the initial investment strategy.

Since the OSD Comptroller is a major player in the budgeting and investment planning process, and will probably

remain so for some time, it is important to make sure that he gets the information he needs to make the best possible decisions. When asked what type of information he would like to see during budget reviews, David Howen, an analyst from the OSD Comptroller office, replied that he wanted to know total costs for a program. His major concern was that in order to be able to compare program performance, he needed to have what he called a "level playing field". By that, he meant that it would be unfair to compare costs of operating a laboratory which is a small, tenant organization to those costs directly attributable to a laboratory that may be the major organization on a military installation. In the latter case, most of the costs of security, maintenance, and utilities are paid directly by the lab and the costs appear to be much higher (Howen, 1991).

So far, only the formal lines of communication have been discussed. There are many informal lines. In fact, much of the process is informal (ad hoc). The Air Force S&T program is run on an exception basis. That is, it is assumed that everything is going according to plan unless someone is told otherwise. The scenario goes something like this. Someone in Congress may ask why the military hasn't been able to fix a certain problem with engines stalling in high performance aircraft. The AFAE staff will start to answer the question by reviewing the projects currently under way in the laboratory to fix the problem. They may also want to find out how far along the project is and if

there have been any significant problems. The staff doesn't usually have the most current information, so they call the TEO staff. The TEO staff also doesn't usually have the most current information, so they call the program element manager. The program element manager at the laboratory may, or may not have the most recent information. He may have to contact the individual project manager. If the project manager is on top of the project, he may be able to give an answer. If not, he may call the project manager at the contractor facility. Sometimes information is requested of the program/project manager from all levels of S&T. This can be seen in Figure 13 where the manager is asked to

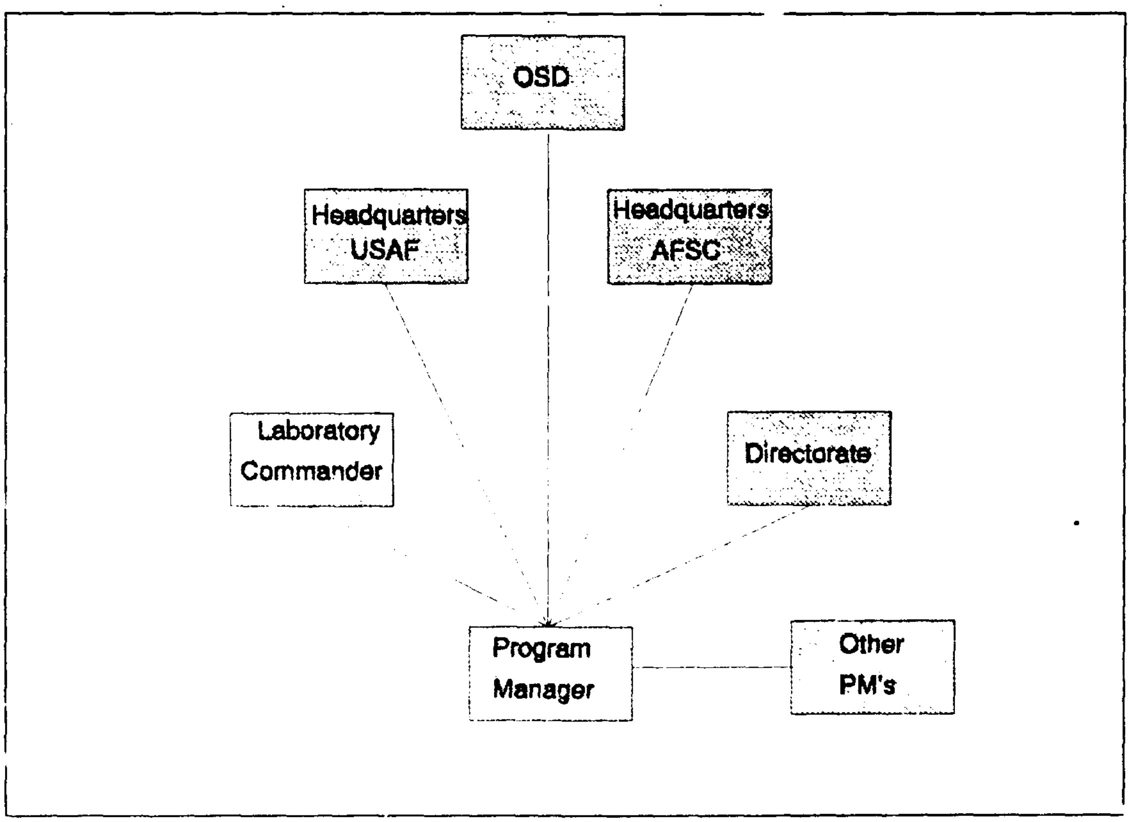


Figure 13: Requests for Information

provide briefings, talking papers, and in some extreme cases is even asked to write the Program Management Directives (PMD) and Descriptive Summaries which become AFAE documents.

Why does it appear that no one at the upper levels of management has up-to-date information? Even in the case of quarterly reports, the information is old before it is printed. If the project is under contract to industry, the company has approximately 30-45 days from the end of a fiscal quarter to submit its quarterly report. These reports are then aggregated into a quarterly report for the program element, or in some cases program. This process may take 30 more days. By the time the programmatic information gets to the headquarters staff, it is more than two months old.

What Figure 12 does not identify is the timing of the feedback. For instance, it doesn't show whether or not the feedback is weekly, monthly, or yearly. Other than the quarterly reports submitted by the 6.3A program managers, the formal feedback is annual, usually in the form of a briefing.

Developing and Scoring the Options

With a better understanding of the S&T organization, it is time to move on to discussing policy options. These will be evaluated for possible consideration as a means to help the S&T program operate better. This section begins with a review of the decision criteria.

Decision Criteria. There is no such thing as a perfect policy. Policies contain both strengths and weaknesses. Therefore, it is important, for evaluation purposes, to develop decision criteria which can used to score each policy. Criteria are used so that one policy is not scored directly against another. This same technique is used in evaluating contract proposals in the government, but for a different reason. In evaluating contracts, it is important to score a proposal against set criteria, since the government cannot ask Contractor A to submit a better proposal than Contractor B simply because Contractor A should have no idea of what Contractor B was submitting. For the purpose of this research, the decision criteria simplify the evaluation process. For instance, if there are four policies to be evaluated, and they are to be scored against each other, there are seven different ways that they can be paired for comparison. Using pre-established decision criteria reduces the number of evaluations to four.

The criteria used for evaluating the policies in this thesis will be slight modifications of the seven criteria used by Peter Drucker (Drucker, 1974) to evaluate management control systems, which were described in Chapter II. These criteria are briefly repeated below.

Economical. The cost of implementing the policy should not exceed its benefits. A low cost policy will score higher in this category than will a high cost policy.

A baseline for cost comparisons will be the current management control system.

Meaningful. Things to be measured must be significant. For instance, if we are trying to determine the operating costs of a $1.5 Billion program, it may not be prudent to count exactly how many sheets of bond paper the organization has used each month.

Appropriateness. Once the policy is implemented, will it measure the things that need to be measured? For instance, if we want to increase efficiency, is it appropriate to measure expenditures?

Timely. Will the control system provide timely information to decision-makers? Even if the information is timely, will it be in a format that the decision-makers can use or understand?

Simple. How simple is it to operate the control system? The simpler the better. The more complicated the system, the more apt you are to receive information that is incorrect.

Operational. Can the control system be implemented without changing the current accounting system? Will all levels of management "buy into" the system (goal congruence)? How easily can the system be manipulated or "gamed"?

Because no sponsor existed for this research, the researcher assigned weights to the criteria based on past

personal experience. The following weights have been assigned to the criteria.

Economical	(.10)
Meaningful	(.10)
Appropriate	(.25)
Timely	(.25)
Simple	(.10)
Operational	(.20)
Total	1.00

Now that the decision criteria have been reviewed and weighted, it is time to discuss the different policy options.

Performance Measurement Options.

Unit Costs. Unit costs are determined by creating a ratio of inputs to outputs to make a dollar per unit value, assuming that inputs are in terms of dollars. Individual laboratory unit costs can be determined by taking the total dollars input into that particular lab and dividing by its total output for a period of time. Performance is then measured by this calculated unit cost. The lower the unit cost the better. This performance information could then be used for resource allocation decisions. For instance, if you assume that two facilities have identical outputs, and one has lower unit costs than the other, management could decide to use the facility with lower unit costs at its maximum capacity. If organizations do not produce identical outputs, the unit cost information can be used as a baseline from which to set goals for improvement. This would create a situation in which an

organization is in competition with itself, instead of competing with another organization, which should still emphasize increased efficiency.

Programmatic Feedback. This option would use cost and schedule information with regard to laboratory research efforts, both in-house and on contract. Performance is measured by comparing actual to planned costs and schedules. This information could then be used for resource allocation decisions. It should identify lazy money that could be moved to efforts that need additional help. It may also help identify programs that need to be canceled, along with the impacts of such cancellations.

S&T as Overhead. This option treats the Science and Technology program as part of the overhead of a Product Division. In the case of Wright Laboratory, the Product Division would be Aeronautical Systems Division located at Wright-Patterson AFB, Ohio. This option makes the assumption that S&T is so small that it does not make sense to spend a tremendous amount of time and money to apply more management than is accomplished currently. Performance would be measured by reductions in overhead (inputs) while maintaining a current level of output. In some respects this option is like the unit cost option because it deals with inputs and outputs, except that in this case, the output is fixed and only the inputs are addressed.

Each of these performance measurement policy options has unique features. Next, we will score the options against the decision criteria.

Scoring the Options. Scoring the performance measurement options was accomplished using the six criteria discussed earlier in this chapter. Raw scores for each criteria were assigned using a scale of one to ten, with ten being highest. Each raw score was then weighted and summed to give a total net score. The highest total score possible for any policy option was a 10. For the purpose of evaluation, each policy started with a score of 5.0 for each criteria. Points were added or subtracted depending on whether or not the policy option was judged to be better or worse than the one currently in use. The raw score is shown in parentheses after each criterion.

Unit Costs.

Economical. (4 points) - Up front, this option will require a major study to identify both direct and indirect operating costs. Much of the effort will be devoted to identifying and separating indirect prorated shares of the host base operating costs, and direct costs of each laboratory.

Meaningful. (5 points) - This option places emphasis on measuring output, which is good. It does not, however, address the effectiveness of the output. Another matter that must be addressed is whether different outputs should have different weights assigned to them for

calculating total output. For instance, is a journal article worth more than an hour of consultant time? Is one journal article worth two technical reports?

<u>Appropriate</u>. (3 points) - An intriguing feature of this option is that it should identify a point at which laboratory performance begins to decline due to combinations of inputs and outputs. To see why this is so, assume that a laboratory has $200 Million in inputs and, say 1000 outputs (whatever they are). The unit cost for these outputs would be $200,000. If the laboratory is able to cut its overhead/operating costs so that its inputs for next year are only $175 Million, at first glance, it might appear that the lab has done a good job. If, on the other hand, the lab outputs dropped during this same period to 750, the new unit cost would be $233,333. An increase of 16.67% even though the inputs dropped 12.5%! What this shows is that there should be a point at which managers can combine inputs and outputs to reach a minimum unit cost. Currently there are no incentives, other than not getting a budget cut, to a manager to reduce costs, according to Richard Hill, program manager in the Aero Propulsion and Power Lab (Hill, 1991). Unfortunately, units costs can be driven by external factors beyond the manager's influence. Timing of projects could be such that they are all in the final phase of completion when the year ends. No technical reports would have been accomplished and therefore laboratory unit costs would appear high. The Congress could decide to intentionally

stretch out a project's schedule, or surprise the laboratory with a new MILCON project. This will cause higher unit costs which are not under the control of the manager.

Timely. (3 points) - Unit costs can only be measured after-the-fact. It would make no sense to calculate a unit cost during the middle of the year, if a great deal of your output occurs at the end and most of your costs occur in the beginning. This unfortunate feature does nothing to aid the decision-maker during the year. Unit Costs are best used at the end of the year.

Simple. (4 points) - Fairly straight forward approach. Everyone understands the idea of inputs and outputs, but S&T requires the development of a "knowledge unit", described below, as a unit of output. Such a measure may not be understood by decision-makers outside of S&T.

Operational. (3 points) - The hardest thing about implementing this option is identifying the inputs and outputs of a laboratory. The goals of the S&T program identified by General Yates, Commander of Air Force Systems Command, provide a starting point to understand the complexity in this issue.

Appendix B contains the vision for the Air Force laboratories. Looking closely at the document, it is difficult to identify anything that resembles an output. For example, it talks about having world class research facilities, but facilities are not in themselves an output. It does mention that the labs will interact with several

organizations, such as industry, customers, development planners, program offices, and others. This goal is probably closer to identifying an actual output than the others. Let's take a close look at what the lab output actually is.

Laboratories don't develop prototypes. They don't transition technology directly to weapon systems, although there may be a few exceptions. Fundamentally, the output of laboratories can be described as knowledge. Laboratories transition knowledge to industry who then can design, manufacture, and sell the technology to their customers. These customers may or may not include the Department of Defense. How do you measure knowledge? It may be impossible to measure directly, but there are some indirect measurements that are possible. Knowledge of technology development in labs is shared through media such as technical reports, professional journal articles, symposia papers, patent applications, and most importantly, through laboratory personnel acting as expert consultants. Reports, articles, papers, and patents can be measured directly. Consultant time can be measured through the use of the Job Order Cost Accounting System (JOCAS) used in the lab. The JOCAS keeps track of which jobs the lab personnel have worked, in hours. According to Lt Col. Whitcomb, Director of Operations for Wright Lab, this system is currently used to bill outside organizations for reimbursable costs for research (Whitcomb, 1991). This same system can account for

these transactions as consultant work. The total hours spent on such projects can then be counted as an output for the lab. Let's now turn our attention to determining the inputs to labs.

Inputs need to be broken down into direct and indirect. Direct inputs are such things as materials, personnel, and facilities. Materials can be identified as anything from office supplies to raw steel and their use can be tracked through the resource management system. Personnel costs should be fairly straightforward, except for the fact that military personnel costs are not currently accounted for as project costs. Civilian costs can be prorated to a project based on an hourly rates, but military costs are not generally calculated in this way. A simple way to handle this would be to base the military costs on a 40 hour work week, just as the civilian costs are, and track these hours through the JOCAS. Facility costs are another matter of concern. For the most part, laboratories do not directly purchase their major facilities. These are funded by of the Military Construction (MILCON) appropriation. Utilities (gas, electric, water) are also not directly paid for by the laboratories. Neither is maintenance of the facility, unless the local Civil Engineer runs out of money (Mitchell, 1991). For the concept of unit costs to work, all of these facility costs must be included in calculating the costs per output. Utilities and maintenance cost accounting shortcomings can be remedied by having the laborator es

reimburse the host organization for these services. Accounting for facilities is another matter, however. Laboratories should account for the facility cost, but not in one lump sum. Such a lump sum accounting would cause a tremendous spike in the unit cost calculations and make them next to useless for keeping track of performance. The facility costs should be depreciated over several years to better match the facility costs with actual use.

Indirect costs are such things as prorated shares of hospital, fire department, commissary, and other base service costs supplied by the host unit that can be attributed to the laboratory. The determination of these indirect costs may require a major study which should break out the indirect costs by civilian and military categories. When the OSD Comptroller talked about a level playing field, he was talking about these indirect costs. Only after taking these into consideration can a true apples-to-apples comparison of organizations take place using unit costs (Howen, 1991).

According to Walker Mitchell, managers are opposed to this option due to a fear of the impact of unit cost comparisons between directorates, or even labs. He also stated that this type of system can be gamed by having journal articles submitted several times to different journals under different titles, although this may not actually be bad since the article could potentially reach different audiences. The concept of transferring knowledge

requires that research failures also be published, since they could actually be quite valuable to further research. Scientists will not publish their failures according to Walker Mitchell (Mitchell, 1991). Another way to game the system would be to significantly reduce operating costs by cutting all military positions from the laboratory. This would eliminate the prorated shares of military support facilities.

Programmatic Feedback.

Economical. (5 points) - Data for reports is readily available and will require no change to the current accounting system. More time may be required by management to prepare the additional reports, but this may be offset by the time savings due to multiple requests for similar information from various levels of management.

Meaningful. (6 points) - This is a significant improvement in managing resources based on actual work accomplished to date and not by obligation/expenditure rates.

Appropriate. (6 points) - This concept will provide early detection of problems in projects and force managers at both the directorate and laboratory level to play a more active role in the management of such projects. It will also force program element managers to get current performance information instead of waiting for outdated quarterly reports from the contractors. As far as efficiency is concerned, the use of planned versus actual

costs and schedules will reflect a more accurate measurement of actual work accomplished than the currently used obligation and expenditure rates. This formal feedback also provides decision-makers with a document from which they can make their decisions. Any up-to-date information needed can be obtained by asking for updates to the reports. This option allows for effective measurement of program performance, as well as the performance of the responsibility centers (labs). It doesn't address the effectiveness of the program, however.

Timely. (8 points) - Each level of management could get information in a timely manner. Only minor updates would be required under crisis situations. This represents a significant improvement over the current system.

Simple. (8 points) - Feedback flows along formal lines of communication. This will reduce confusion and duplication.

Operational. (8 points) - This concept requires that a formal feedback system be institutionalized within the Air Force S&T program. As a minimum, cost and schedule information, planned versus actual, by program element, should be formally reported for both 6.2 and 6.3A projects. Laboratory Commanders should receive these reports at least monthly from each of the program element managers. In turn, the Laboratory should submit an aggregate report quarterly to the Headquarters. These

reports should identify the overall status of the program, but could single out any individual projects that have deviated from the planned cost and schedule by plus or minus 10 percent. The reports should also require an explanation of why the deviations exist and what is being done to correct them. This option requires more formal reports than the current system, but if it cuts down on confusion and duplication of effort, the managers at each level should readily accept the concept.

Laboratory as Overhead.

Economical. (8 points) - This requires very little paperwork to implement as far as the laboratories are concerned. The accounting system will require no change, although the bookkeeping will be different. This option could also reduce some manpower positions by moving planning functions to the Product Division.

Meaningful. (7 points) - This option greatly simplifies the accounting process for Air Force S&T. It is also easier to understand since the Product Divisions have a measurable output (ASD procures such things as aircraft). Some also might argue that a great deal of effort is currently expended to manage a small (less than 1.5% of the AF total obligation authority) portion of the Air Force budget.

Appropriate. (2 points) - This option does very little to emphasize costs. Managers will be reduced to scrutinizing overhead of overhead, which may actually cause

costs to get worse due to lack of attention. This option does nothing to address the effectiveness of lab programs. Efficiency will be addressed through assuring that there is no duplication of effort within the laboratories and identifying and eliminating excess staff positions.

Timely. (5 points) - Timing is not addressed in this option. It is assumed that it should not be any better or worse than the current system.

Simple. (10 points) - This concept is very simple to understand and implement.

Operational. (2 points) - A major drawback to this option is that in order to treat S&T as overhead, it would require the elimination of micromanagement by OSD and Congress. One way this could possibly happen is by significantly reducing the number of Program Elements to one per Product Division. This is not likely to happen. Reduction of Program Elements has been studied by Major Generals Ferguson and Rankine (former and current TEO for S&T), and both decided it was not worth the suffering to attempt the change. Historically each time program elements have been merged, Congress has cut the funding regardless of the explanation given (Cochoy, 1991).

Figure 14 shows the raw and net scores for each option.

Summary

Executive policy within the Air Force Science and Technology program follows a very traditional path from top

	Raw Scores				Net Scores		
	Policy Options *				Policy Options *		
Criteria	1	2	3		1	2	3
Economical	4	5	8		.40	.50	.80
Meaningful	5	6	7		.50	.60	.70
Appropriate	3	6	2		.75	1.50	.50
Timely	3	8	5		.75	2.00	1.25
Simple	4	8	10		.40	.80	1.00
Operational	3	8	2		.60	1.60	.40
				Totals	3.40	7.00	4.65

*

1 = Unit Costs

2 = Performance Feedback

3 = Lab as Overhead

Figure 14: Scores for Policy Options

to bottom of the S&T organization. Programmatic feedback, on the other hand, travels in anything but a predictable line. Much of the programmatic feedback to higher management levels is ad hoc and can be provided only by the program manager because there are no formal lines of feedback within the organization that could provide this information. Real-time resource allocation decisions must be made at various levels of management and managers need better programmatic information to make informed decisions. Each of the three policy options were evaluated against the six decision criteria, of which appropriateness, timeliness and ability to operationalize the policy were weighted higher than the others. The next chapter makes

recommendations based on the evaluation and discusses implementation implications.

V. Conclusions and Recommendations

Conclusions

The analysis in the previous chapter has shown that unit costs are not as effective as using a disciplined method of reporting programmatic feedback when it comes to measuring the efficiency and effectiveness of the Air Force Science and Technology program. This is not to say that the unit cost option is inappropriate for other Air Force programs. It has many good features. Identifying total program costs is one. Its main shortcomings were in the area of being able to properly identify inputs and outputs for S&T. The ability to properly identify all relevant costs is extremely important for making apples-to-apples comparisons of competing programs. Reducing the S&T program to overhead status is also not the best option available. Although it is simple in concept, it does not emphasize efficiency adequately and does nothing to address effectiveness. It would also be very difficult to operationalize if history is a good predictor of the future.

Limitations of Research

There were several severe limitations to this research. First, there was no sponsor. In a normal policy analysis, the analysis is done with a specific decision-maker in mind. The analysis would then be tailored to that individual or

organization. Specifically, both the decision criteria and the weighting could be different. The entire scoring portion of the analysis is subjective and could change depending on who is doing the analysis. Scoring should best be done by persons who would have to use or implement the policy. A second major limitation to the research was that there was a time restriction. Rather than only choosing three policy options, it might have been better to get several options through various methods (brainstorming etc.) and compare three at a time, scoring them against each other. After a policy option is selected as being better than the other two, two different options are introduced and the process is repeated until the best policy is selected. This is why the analysis stops short of recommending the programmatic feedback option. It may not be the best for S&T.

Recommendations

This research identified some areas for future research. First, there is a need to identify direct and indirect costs at Wright Laboratory. Second, if unit costs are to be implemented sometime in the future, an acceptable measure of laboratory output needs to be determined. This would also have to include any weighting of individual efforts, such as articles versus hours of consultant work. Third, this research might be repeated with a sponsor who is willing to help with scoring the various policies.

Appendix A: AFAE Guidance Letter

DEPARTMENT OF THE AIR FORCE
WASHINGTON DC 20330-1000

OFFICE OF THE ASSISTANT SECRETARY

JUN 7 [illegible]

MEMORANDUM FOR AFSC/XT

SUBJECT: AFAE SCIENCE AND TECHNOLOGY EXECUTIVE GUIDANCE - ACTION MEMORANDUM

The Air Force Science and Technology (S&T) program is the cornerstone for our future warfighting capability. We are faced with a rapidly changing world political situation and are entering a period of reduced total Air Force budgets. Within our funding, we must balance developments for future generations of weapon systems (revolutionary and evolutionary) and modification to existing systems (evolutionary). **Our programs must reflect our support and commitment to the OSD Critical Technologies and Investment Strategy.** I know that there are many demands on our program ranging from the OSD Investment Strategy to dual use technology. While we will work to meet these obligations **we must never forget that our number one priority is to serve the operational Air Force.** You have done a fine job in working with the MAJCOMs and we must continue to strengthen those ties.

In our recent reviews of the S&T program it was abundantly clear that high quality work is found throughout the Air Force laboratories. This is a result of the excellent leadership and the outstanding scientists and engineers we have at the laboratories. However, our success stories and accomplishments are not being adequately publicized. We all must work together to present examples of our accomplishments with strong answers to the "so what" question to our corporate leadership. Programs with strong military and civilian applications should be highlighted. Up-to-date cameo briefing charts may be the means to get these success stories out. Laboratory Domestic Technology Transfer programs should be emphasized to ensure that our appropriate technology is available for commercialization.

The Laboratory Demonstration Program is a new opportunity for us to correct many of the bureaucratic problems that we have complained about for years. Rome Air Development Center and Wright Research and Development Center were selected as our demonstration labs and we will support them fully. The successes and failures of the demonstration activities at these centers will influence all of our labs for many years to come. All the labs and centers must interact with the demonstration labs during this period for the Air Force to get the maximum benefit.

In order to increase our effectiveness we will continue to support the three pillars of your investment strategy: people, facilities and programs. The Laboratory Demonstration Program is

an excellent opportunity to explore new ideas in these areas. Civilian and military PhDs must be recruited faster than we are losing them. Palace Knight is a step in that direction. Continue to push Palace Knight and a dual track S&T professional development program for both civilian and military. Work with AFIT to establish more military PhDs.

Appropriate modern facilities for research are important in getting and keeping these high quality people. The facilities are also critical to our ability to provide the Air Force with the right future technology. We must have an independent Air Force laboratory research capability at the same time that we support development of technologies by contractors. We will continue to work the facilities issue with you. However, we must consider only those options that do not place our tight S&T funding at undue risk.

Our laboratory leadership must make maximum use of their flexibility for quick reaction to the changing environment/ technology. The labs should increase the use of Broad Agency Announcements and Program Research and Development Announcements to get ideas from industry. The In-House Laboratory Independent Research program should be used to fund targets of opportunity in basic research coming from the lab personnel.

The attachment provides the latest draft of our regulation on S&T acquisition, including the Technology Area Plan (TAP)/Technology Investment Plan (TIP) process. A $1M AFAE approval threshold for in-cycle TIPs is established. This draft will be used during the upcoming year and changes can be incorporated before issuing the regulation formally.

The TAPs were much improved this year. I am very pleased with the general format; however, the global strategy and vision for some technology areas appear to be lacking, particularly for software, air vehicles, conventional munitions, and space and missiles. The roadmaps are the most critical part of the TAPs with the top level roadmaps conveying the global strategy. The second level roadmaps, which are key to my staff's understanding the programs, need significant work in some cases. These roadmaps must tie together the TIPs and the thrust writeups in the TAPs.

It is most important for each laboratory to continue to produce a TAP-like document, because of their great utility in our interactions (by PE) with OSD and Congress. Building broader technology area plans and roadmaps is a good idea, if it can be done without undue extra effort. The roadmaps for these broader areas as well as specific areas that cross laboratories would also be beneficial in explaining our global strategy. Please identify potential candidates for these plans and/or roadmaps and determine the most feasible product.

The technology efforts funded by the National Aero-Space Plane **(NASP) program should be included in the TAP process to**

demonstrate the technology flow between the NASP program and the other parts of the S&T program.

The proper balance between the 6.1, 6.2, and 6.3 Advanced Technology Development (ATD) programs must be maintained. Within this balance we meet both the Air Force's need for improvements to current systems and the need for next generation systems. In the present fiscal environment, my highest priority will be the 6.1 and 6.2 programs. **We must continue our policy for a stable basic research program with no negative real growth.** The 6.3ATD programs will be structured so that they have clearly defined goals, critical experiments, technology transition, and insertion roadmaps developed with strong user support. This includes demonstrations that support upgrades to existing systems. We must plan to improve fielded systems in the constrained budget environment.

These areas need **increased attention**:

a: System support areas such as fuels and lubes, power supplies, environmental effects, and reducing dependence on hazardous materials, with emphasis on halon replacement.

b. **Mechanical and electronic systems and subsystems support**, including **system reliability and maintainability, to increase survivability and repairability**, thus **increasing sortie generation, lowering life cycle costs, reducing maintenance actions, and improving subsystem durability**.

c. Near term avionics upgrades; survivable, assured communications; photonics; noncooperative identification; automatic target recognition; tracking low observables/small low flying vehicles in combat situations; and near term improved 20 mm ammo.

d. Technology to reduce the cost of space operations, to include the Ram Cannon concept (which also has potential for other applications)

While our Integrated High Performance Turbine Engine Technology program is producing useful results, we must gradually increase the proportion of our propulsion program that supports next generation technologies such as combined cycle engines and hypersonic ram jets for the post 2000 era.

We need to continue to examine our program and see if there are areas that can be reduced or cut. As a start, Electromagnetic Pulse testing, nuclear safety reviews and nuclear criteria and feasibility studies should be removed from the Weapons Laboratory program.

J. J. WELCH, JR.
Assistant Secretary of the Air Force
(Acquisition)

1 Atch
Draft Reg

Appendix B: AFSC Goals for S&T

THE VISION FOR OUR AIR FORCE LABORATORIES

Our laboratories will provide the technical leadership in the transition of new technology to war-fighting systems. We will accomplish this by:

- Conducting long-term, high-payoff research,
- Developing technologies for product development and maintenance, and
- Providing in-house technical expertise for the Air Force.

We create Science and Technology (S&T) programs in response to our users' requirements, higher headquarters guidance, and our own enlightened view of high-payoff technologies.

Our laboratories will:

- Be world-class research organizations in technical areas of vital importance to future Air Force capability needs.

- Create environments that facilitate free and open interaction among scientists and engineers who must cooperate to invent the interdisciplinary weapon systems of tomorrow.

- Recruit and retain the finest scientists and engineers with the skills essential to exploit the technology upon which our future weapon systems will be built.

- Have quality facilities in which to perform the excellent work expected.

- Have a strong coupling with industry, users, academia, development planners, other laboratories, systems program offices (SPCs), and product development engineers. Therefore, our laboratories will:

1. Contract with industry to ensure industry can possess, propose, and produce technology essential to the Air Force.

2. Interact with users to ensure laboratories:

   - Understand users' future needs.
   - Keep them aware of new opportunities.
   - Help them fix their current problems.

3. Conduct in-house research to ensure they

   - Can invent new technologies.
   - Deal equitably with university peers and gain insight into their research.
   - Pick the right technologies to exploit.
   - Are educated buyers of contracted technology.

4. Interact with Development Planners to ensure we can insert new technology into weapons concepts.

5. Interact with other service and agency S&T organizations to ensure we:

   - Coordinate research and share progress.
   - Resolve overlap and exploit opportunities for cooperation.

6. Interact with SPCs and Product Development Engineers to ensure we

   - Identify technical risks to be reduced.
   - Identify preplanned product improvement (P3I) opportunities.
   - Help them fix their current problems.

RONALD W. YATES, General, USAF
Commander
Air Force Systems Command

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VITA

Captain Michael Patrick Avery was born March 19, 1957 in Saginaw Michigan. He graduated from Reese High School in Reese Michigan in 1975. In 1977, he enlisted in the United States Air Force and was assigned to the Air Force Academy, where he worked as a support records clerk in the base supply system. In 1980, he entered the Airman Education and Commissioning Program and attended the University of Florida where he graduated in 1983 with a BS in Aerospace Engineering. After his commissioning through the Officer Training School in 1983, he was assigned to the Aero Propulsion laboratory at Wright-Patterson AFB, Ohio. While there, he worked in the Turbine Engine Division and managed two joint, Air Force/Navy advanced technology development projects. In 1987, Captain Avery was assigned to Headquarters Air Force Systems Command, Andrews AFB, D.C., where he was the manager for Aeropropulsion and Power research and development programs, and in 1989 became the executive officer for the Chief Scientist where he was deeply involved with the Laboratory Consolidation Study directed by the Secretary of Defense. Captain Avery received a M.S. in Public Administration from Central Michigan University in August of 1989. He entered the Air Force Institute of Technology in May 1990.

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13. ABSTRACT (Maximum 200 words)

This study investigates the possible use of unit costs as a means of performance measurement in the Air Force Science and Technology (S&T) program. Using a policy analysis methodology, the author breaks the analysis into four phases. The first phase is called understanding the problem and incorporates the theory of management control systems, budgets, resource management systems, and identifies what the S&T program encompasses. The second phase is called developing policy options and identifies three distinctly different policies that satisfy the need for getting performance information into the hands of decision-makers. The third phase is called determining the impacts. During this phase each of the policies is evaluated based on weighted decision criteria and possible impacts are identified. The last phase is called selecting the best alternative. This phase states the conclusions reached from the analysis. It also identifies the limitations of the research and recommends areas needing further research. This study found that unit costs are currently not the best way to determine S&T program performance. The technique of unit costs is currently not possible to implement because of a lack of total operational cost data and an undefined measure of laboratory output.

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1. Did this research contribute to a current research project?

    a. Yes   b. No

2. Do you believe this research topic is significant enough that it would have been researched (or contracted) by your organization or another agency if AFIT had not researched it?

    a. Yes   b. No

3. The benefits of AFIT research can often be expressed by the equivalent value that your agency received by virtue of AFIT performing the research. Please estimate what this research would have cost in terms of manpower and/or dollars if it had been accomplished under contract or if it had been done in-house.

    Man Years ____________ $____________

4. Often it is not possible to attach equivalent dollar values to research, although the results of the research may, in fact, be important. Whether or not you were able to establish an equivalent value for this research (3 above), what is your estimate of its significance?

    a. Highly Significant   b. Significant   c. Slightly Significant   d. Of No Significance

5. Comments

____________________   ____________________
Name and Grade   Organization

____________________   ____________________
Position or Title   Address